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THE CAUSE OF PULSATION

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THE following is an account of a research which was pursued at the Marine Laboratory of the Carnegie Institution at Tortugas, Florida.

An interesting jellyfish, *Cassiopea xamachana,* lives upon the muddy bottoms of the lagoons of coral islands in the Florida and West Indian regions. Here the stilted roots of dense green mangroves fringe many a lagoon whose half stagnant waters have never felt the surge of ocean waves. Looking down through the clear depths one sees the bottom almost carpeted with the *Cassiopea* medusæ. Over wide areas they lie with their disks nearly touching and their bell-rims languidly pulsating. At a glance one might mistake them for sea-weeds, deceived as one would be by their delicate blue-green and gray-blue color, and by the tree-like shape of the branching appendages which bear the mouths of the medusa, and which project upward and outward hiding the pulsating disk below them.

At regular intervals around the rim of the jellyfish we find about sixteen minute club-shaped organs, each set within a deep niche. The microscope serves to show us that each of these little clubs contains at its outer end a mass of crystals, and upon one side a simple cup-like eye. Even in medusæ six inches in diameter these sense-clubs are smaller than the heads of the smallest pins; mere specks barely discernible to the eye, yet if they be cut off we find that the medusa ceases to pulsate, while the cut-off portion of the rim still contracts rhythmically. It is thus evident that the stimulus which produces each and every pulsation arises in the sense-clubs.

The question is, why is it that the central disk of the medusa does not pulsate in sea-water when its sense-clubs are removed? Curiously enough, if we stimulate the disk in any manner, such as by a mechanical or electrical shock, or by touching it with a crystal of common salt, it gives a few vigorous pulsations and then lapses into quiescence.

But if we cut out the center of the medusa and also remove the rim, thus forming a ring tissue without sense-organs (Fig. 2), this

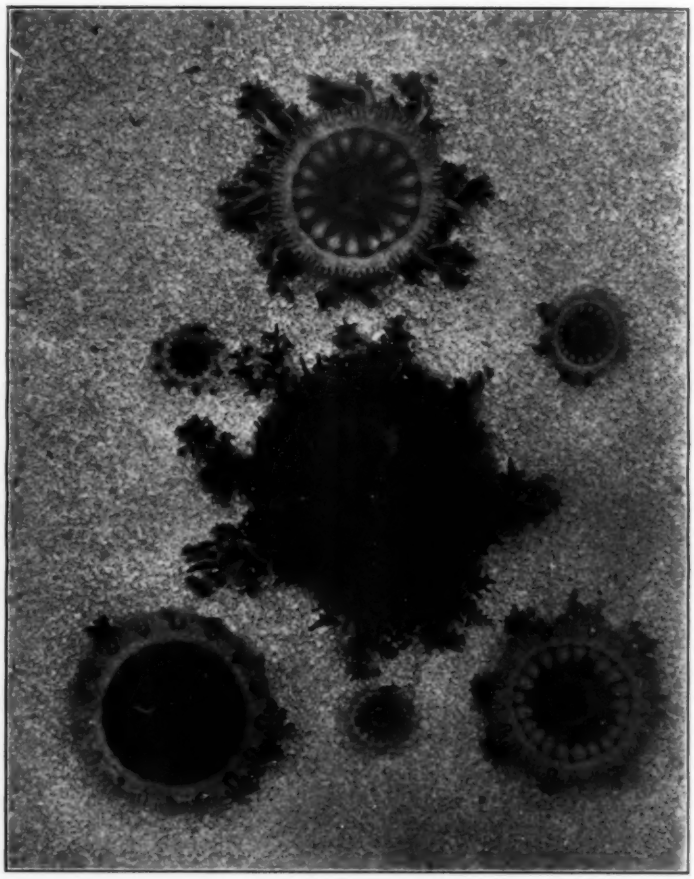

FIG. 1. LIVING MEDUSÆ OF *Cassiopea xamachana* ON A SANDY BOTTOM. The large medusa in the middle is in the natural attitude with its mouth-arms uppermost. The smaller medusæ have been turned over in order to show their pulsating disks.

ring remains quiescent in sea-water unless we stimulate it at any point such as at *S* with a single momentary touch of a crystal of potassium, or in some other manner, when a contraction-wave starts out from the point touched. In a narrow ring, however, the waves can go only in opposite directions from the stimulated point. Now one of these waves is apt to be strong and the other weak; for the nervous network which

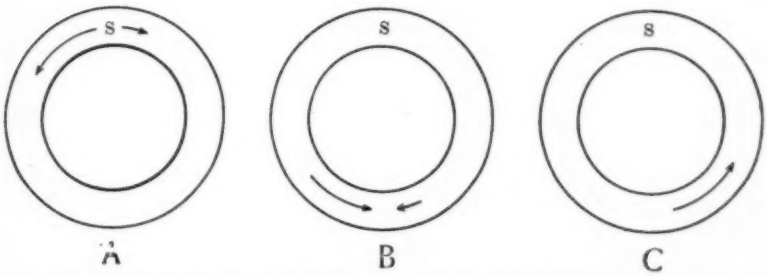

FIG. 2. SHOWING HOW A PULSATION-WAVE MAY BE "ENTRAPPED" IN A CIRCUIT OF TISSUE.

transmits them is almost certain to be more complete on one side than on the other of any stimulated point. Of course the waves meet as in Fig. 2, *B*, and then the strong wave destroys the weak one and continues around the ring. There is then only one wave left in the circuit and this travels constantly around (Fig. 2, *C*) for hours or days until something stops it, such as the cutting of the circuit or a fresh stimulus which produces a wave that meets and destroys it.

The weak wave was destroyed by the strong one in the above experiment because a weak stimulus can not set tissue into pulsation, which has been caused to pulsate through a strong stimulus, until after an appreciable interval of rest. Thus a weak stimulus following *immediately* after a strong one will produce no contraction, whereas a strong stimulus may cause tissue to pulsate even immediately after it has responded to a weak one.

It is now evident that the disk without its sense-organs *can* pulsate in sea-water if only a wave be once started in it, but that under normal conditions there is nothing to *start* a wave, and thus the disk remains quiescent. In other words, the sea-water is indifferent, and neither stimulates nor inhibits pulsation.

It is now time for us to determine why it is that the sea-water does not stimulate the disk when its sense-organs are removed. In the first place we must know the composition of sea-water, and chemical analysis shows that it consists of a mixture of sodium chloride (common salt), magnesium chloride and sulphate, potassium chloride, and calcium chloride and sulphate.

Numerous experiments show us that the common salt is a strong stimulant to both nerves and muscles. On the other hand, magnesium, calcium and potassium, all inhibit and do not stimulate the disk. Indeed, the stimulating effect of the common salt in the sea-water is exactly offset by the subduing tendency of the magnesium, calcium and potassium; and thus it is that the sea-water as a whole neither stimulates nor inhibits the pulsation of the jellyfish. The sea-water main-

tains the medusa in a delicately balanced fluid for it contains poisons and antidotes as does our blood, which exactly counteract one the other. For example, the jellyfish dies in less than two hours if placed in a solution having the amounts and proportions of the common salt and the potassium of the sea-water, but if we simply add the calcium it pulsates very rapidly for more than twenty-four hours. Finally, however, the calcium produces so strong a muscular tetanus that the pulsating tissue is torn literally to shreds; but all of these injurious effects disappear when we add the magnesium, which causes the pulsation to become much slower and more regular, and wholly prevents the calcium from producting tetanus. Another curious fact is that were it not for the presence of the calcium the magnesium would so stupefy the nervous and muscular tissue that no pulsation could arise. This is the more remarkable because magnesium and calcium are both inhibitors of pulsation, yet when both are present they tend in a measure to offset each other, magnesium mainly inhibits the muscles, while calcium stupefies the nerves.

But to return to our subject, let us carry out some experiments to discover the nature of the stimulus which produces each pulsation of the jellyfish. If we cut a ring from the medusa's disk such as is shown in Fig. 3 and leaves a long narrow strip *AB* attached to it, and then start a contraction-wave traveling around the ring; every time the wave passes the point *A* a side-tracked portion of the wave will pass along the strip from *A* to *B*. When each side-tracked wave comes to the end *B* it dies out, for it can not return over the recently stimulated tissue along which it has just passed. Thus we see that the index strip *AB* simply serves to catch a portion of each wave which passes its base.

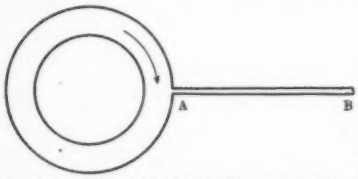

FIG. 3. A PULSATING RING WITH AN "INDEX-STRIP."

Now suppose we place the ring in a pure solution of magnesium chloride, and allow the index strip *AB* to remain in natural sea-water. Then the contraction-wave gradually dies out in the pulsating ring, for the magnesium paralyzes the muscles; and at the end of about a quarter of an hour all movement will have ceased in the ring, but long after this we find that the strip *AB* still continues to transmit contractions at regular intervals of time. We see then that whenever the something which produced the contraction in the ring comes around to the point *A* it is still capable of setting up a contraction in the strip *AB*, although it can not now cause the muscles of the ring itself to pulsate.

The explanation is that the stimulus which produces pulsation is

nervous in nature, and travels through the nervous tissue quite independent of the presence or absence of the muscles. When therefore the magnesium paralyzes the muscles the nervous stimulus still travels around the ring even though the muscles can not now respond to it by contraction.

We now are in a position to state that each pulsation is due to a nervous stimulus which originates somehow in the sense-organs. The question is, how does it originate?

In all of the large jellyfishes called Scyphomedusæ, the marginal sense-organs are little clubs, the axial cores of which *always* contain a terminal mass of crystals. These crystals consist of calcium oxalate with a slight addition of uric acid and urea. The uric elements are relatively inert and need not be further considered. The presence of calcium oxalate, however, acquires some meaning when we find that the sense-organs can not continue to give rise to pulsations unless they be constantly supplied with soluble calcium, and all movement ceases in a few moments if the jellyfish be placed in sea-water deprived of calcium. We see at once that there must be some oxalate which is constantly forming in the sense-organs, and which is precipitating the soluble calcium chloride and sulphate of the sea-water to form the insoluble calcic oxalate crystals of the sense-club.

The question before us is, what oxalate is being formed in the sense-organs? We know that in certain tissues in the bodies of animals oxalic acid, and other oxalates, are formed apparently through the incomplete oxidation of carbohydrates. Now we find that even so small a quantity as one part by weight of oxalic acid in one thousand parts of sea-water paralyzes the sense-organs and permanently *prevents* their giving rise to pulsation, although so weak a solution is not sensibly poisonous to the general tissues of the medusa. Also the oxalates of potassium and magnesium finally inhibit pulsation, and it can not be that any of these is the cause of pulsation in the sense-organs.

The key to the mystery seems to be found, however, when we immerse the sense-organs in a solution of from 1 to 5 parts of *sodium oxalate* in 1,000 parts of sea-water; for this immediately stimulates them into great activity, whereas it has no effect if applied to any part of the medusa other than the sense-organs.

Now *sodium oxalate* precipitates the calcium which enters the sense-organ from the sea-water to form calcium oxalate, and sets free common salt and sodium sulphate; both of which are powerful nervous and muscular stimulants. The chemical formula for this reaction is as follows:

$$Na_2C_2O_4 + CaCl_2 = 2NaCl + CaC_2O_4,$$
$$Na_2C_2O_4 + CaSO_4 = Na_2SO_4 + CaC_2O_4.$$

FIG. 4. WHERE *Cassiopea* LIVES. Lagoon of Bahia Honda Cay, Florida Coral Reef.

Thus the sodium oxalate which forms in the sense-organs is simply changed into ordinary table salt, which acts as a stimulus to produce pulsation.

We can prove experimentally that this suffices to explain the phenomenon of pulsation, for if we simply add from 1 to 5 parts of common salt to 1,000 parts of sea-water, we find that this slight excess of salt acts as a powerful stimulant to the sense-organs, but produces no pulsation if placed upon other parts of the jellyfish.

It thus appears that each sense-organ normally maintains a certain excess of common salt which acts as a stimulus, and which is prevented from becoming too concentrated by the fact that being soluble it is constantly dissolving out into the surrounding sea-water.

It may trouble us for a moment to see why a recurrent pulsation should arise from a constantly present stimulus, but long ago Romanes discovered that a weak constantly present stimulus, such as a faradaic current of electricity, will cause rhythmical pulsation, the jellyfish responding to it periodically and regularly.

We see then that the natural stimulant which produces the pulsation of the jellyfish is only that most familiar substance common salt!

The hearts of higher animals behave in a manner so similar to that of the pulsating jellyfish that we need not be surprised if it be demonstrated that here also a slight excess of *sodium chloride* gives rise to each and every pulsation.

A BIOGRAPHICAL HISTORY OF BOTANY AT ST. LOUIS, MISSOURI[1]

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THE history of botany in St. Louis extends back nearly to the beginning of her political history. The city was founded in 1764, and while it is not as old as most of the other large cities of this country it seems to have been one of the earliest settlements made in the great northwestern region, comprising what was once known as Upper Louisiana. Boston, New York and Philadelphia were already large cities for that time and were centers of botanical activity. In 1795 when Michaux visited the Illinois Territory, Cahokia, Kaskaskia and St. Louis were the principal places west of Vincennes and as late as 1800 St. Louis had a population of less than 1,000. At about this time the fur traders changed their headquarters from Cahokia and Kaskaskia to St. Louis, causing a corresponding increase in population and commercial influence of the latter town.

The Jesuit missionaries were the first white persons to visit the Mississippi Valley and the adjoining country; they undoubtedly explored the Missouri Territory, but probably not so extensively as they did the Illinois Territory. They were versed to some extent in the art of medicine and knew the plants which were generally used for medicinal purposes. They learned the uses of plants new to themselves from their Indian wards, and in this way they must have obtained a considerable knowledge of the plants of the Missouri country. How much farther they may have carried their botanical studies is unknown to the writer. During the period between the founding of St. Louis and the first visit of Michaux to Cahokia there were undoubtedly persons who studied the botany of the St. Louis district. Whether they formed any collections of the plants is not now known and there seems to be no records of any such study.

For all practical purposes André Michaux may be said to have been the first botanist to work in the vicinity of St. Louis.

Botany has passed through a number of distinct periods at St. Louis, as in other places; it can not be said to have had a "pharmaceutical" period, as that stage was nearly past in the general history of the science when the city was founded. The medical properties of

[1] Published by permission of the Secretary of Agriculture.

the plants of the eastern states and of Europe were already well known at the close of the eighteenth century. Of course many new western plants were discovered, the medical properties of which had to be determined; but this was not the main object in making a study of them. We find three distinct periods of botanical work which include the one hundred and thirteen years that have elapsed since Michaux's visit. These may be designated as follows: First, exploration by botanists on transient visits of a few days' to a few months' time; second, collecting by persons who lived in or near St. Louis for a number of years; third, modern botany as contrasted with the purely systematic work of early days. These three periods overlap one another, but can still be distinguished without difficulty. The first includes most of the work done previously to 1850; the second began with the work of Engelmann and his numerous contemporary collector friends, who relied upon him for assistance in naming their collections; it may even be said to extend until the present time, as considerable work is still being done upon the local flora of the district; the third period may be said to date from the founding of the Shaw School of Botany, and the assumption of control of the Missouri Botanical Garden by the board of trustees.

André Michaux, the great French botanist, who explored so extensively the territory of the thirteen original colonies as far west as the Mississippi River, is the first botanical worker concerning whom published records have yet been found as having worked in the vicinity of St. Louis. He is known to have visited Kaskaskia and Cahokia, and the evidence seems to indicate that he must have visited the west shore of the Mississippi, since a few species are listed in his "Flora" as coming from the Missouri River.

André Michaux[2] was born at Satory, near Versailles, France, in 1746. He was destined by his father for the superintendence of a farm of the royal estate, and early became interested in agriculture. Upon the death of his young wife, at the birth of their son, François André, he devoted himself to scientific studies, especially botany. He studied botany under Bernard de Jussieu, and sought in foreign lands for strange plants. In 1779–81 he traveled in England, the Auvergne, the Pyrenees and Spain. In 1782–5 he was in Persia in a political capacity, but really to explore a country at that time almost unknown to scientific men; he intended to return to Persia, but was requested in 1785, by the French government, to introduce into France such North

[2] Hooker, W. J., *Amer. Jour. Sci. and Arts*, 1st series, 9: 266–269, 1825.
Gray, Asa, Ditto, 1 ser., 42: 2–9, 1842.
Coulter, J. L., *Bot. Gaz.*, 8: 181–183, 1883.
Rusby, H. H., *Bull. Torrey Bot. Club*, 11: 88–90, 1884.
Sargent, C. S., "Scientific Papers of Asa Gray," 2: 23–31, 1889.
Thwaites, R. G., "Early Western Travels," 3: 11–19, 27–104, 1904.

American trees as might be of economic importance. In the autumn of 1785 he embarked for New York, accompanied by his young son; here he spent a year and a half collecting plants and starting a botanical garden in Bergen County, New Jersey; he found, however, that the southern climate was more suitable for many of his plants, and he accordingly removed to Charleston, South Carolina, in 1787, where he established another garden, about ten miles from the city. During this year he explored the mountains of the Carolinas; the next he journeyed through the swamps of Florida, and the next he visited the Bahamas, and again searched the mountains for plants of economic importance—especially ginseng. In 1792 he collected around New York and in New Jersey; thence he went up the Hudson to Albany and along Lake Champlain, reaching Montreal June 30, 1792. From Montreal he went to Quebec, and thence by way of the Saguenay to Hudson's Bay. He then returned to Philadelphia, where he proposed to the American Philosophical Society an exploration of the great western territory, by way of the Missouri River. A subscription was begun for the purpose, and Thomas Jefferson drafted detailed instructions for the journey. Michaux, indeed, is stated to have started west and to have proceeded as far as Kentucky when he was overtaken by an order from the French government to relinquish the journey for a political mission. This mission seems to have had for its object the control of Louisiana by the French, through the aid of the trans-Allegheny Americans. In carrying out this plan Michaux made a journey in 1793 to Kentucky by way of the Ohio River, and returned over the "Wilderness" road, and through the valley of Virginia. Early in 1794 he made another extensive tour in the southern states and the North Carolina mountains. In 1795–6 he made a much longer journey, going from Charleston to Tennessee, thence through Kentucky to Vincennes, Indiana, where he stayed from August 13 to 23. From here he went to Kaskaskia, and from there he visited Cahokia and the vicinity. Upon looking over his "Flora Boreali Americana" we find several species of plants mentioned therein as coming from the Missouri River. It seems quite probable then that he must have visited some locality near this river during this trip, as this is the only visit to this section of which we find any mention in his journal. He mentions St. Louis as being in a prosperous condition, but makes no further allusion to it. Except for the evidence of these few species as given in his "Flora," we should not know that he had gone west of the Mississippi River, and this, of course, is somewhat uncertain, as it is very possible that some person at Cahokia, who may have been on the Missouri River, had out of curiosity picked up some strange plants and happened to bring them to Cahokia at the time Michaux was there. He made a short visit here and then went to Fort Massac, near the mouth of the Tennessee River, and from

there proceeded up the Cumberland River by boat, as far as Clarksville; he then visited Nashville, Knoxville, Louisville, and Morganton, finally arriving at Charleston again in April, 1796. During all of this time he collected eagerly, and more or less extensively. His journals, however, give no indications of the species or the number of them found at Cahokia. He seems to have found a considerable number at Kaskaskia, at which place he spent most of his time while in Illinois. In his "Flora" we find mentioned about 100 species as occurring in the Illinois territory; this, however, at that time included all of the territory north of the Ohio which was visited by Michaux. This seems to have been his last extensive trip in America; and in August, 1796, he embarked for Amsterdam and was shipwrecked on the coast of Holland. He is said to have been nearly drowned himself, and a large part of his collections were lost. He remained in France for several years, studying his collections and preparing the manuscript for his "Flora." In 1800 he joined an expedition to Australia, but, becoming disgusted with the management, he landed on the Island of Mauritius, but from there he soon went to Madagascar; here he established a botanical garden and began collecting extensively; but he soon fell victim to the unhealthy climate, and died on November 13, 1802.

Michaux probably traveled more extensively in North America than any other early botanist. He was the author of numberless new species and many new genera of American plants. Unfortunately, the genus, *Michauxia,* which commemorates his name, is one discovered by himself in Persia; so that his name is not thus associated with North American botany, which was so greatly advanced by his studies and explorations.

Immediately following the exposition held at St. Louis in commemoration of the purchase of Louisiana from France, there was held another exposition upon the Pacific coast to celebrate the centennial of the arrival of the Lewis and Clark expedition at the mouth of the Columbia River. This expedition was the first to penetrate overland to the Pacific coast and the results of its successful termination were of immense importance to the entire northwestern country. The journals of the expedition contain many references to plants seen, and especially to those which were peculiar or interesting, or which were used by the Indians.

In the previously mentioned attempt at the exploration of the northwest country, Michaux was to accompany the party. In the expedition which finally did make the journey there was no person who could be called a botanist. Although Captain Lewis was a very keen and observant man, he could not overcome his lack of botanical training, and the results in this regard were hardly what they would have been had Michaux been with the expedition. The journey up the Missouri River was made in boats manned with oars and, owing to the rapid current of

the river, progress was slow, thus affording opportunity for a considerable amount of collecting to be done. During the ascent of the river quite an extensive collection of plants was made, but this had to be left behind when the Rocky Mountains were crossed, and was consequently lost. During the much more hurried return of the expedition another collection was made, but it was much smaller than the first, and comparatively few species seem to have been collected about St. Louis. While this expedition did but little for St. Louis botany directly, it turned the public attention to this section, and finally led to careful botanical exploration by a number of capable botanists a few years later.

Captain Meriwether Lewis[3] was born near the town of Charlottesville, Virginia, on August 18, 1774. His family was one of the most

FIG. 1. CAPTAIN MERIWETHER LEWIS; from *Analectic Magazine and Naval Chronicle*, Vol. 7, 1816.

distinguished of that state. Several of his uncles were very prominent in their time, one of them having married a sister of George Washing-

[3] Jefferson, Thomas, "Biography of Capt. Lewis in Analectic Magazine and Naval Chronicle," 7: 329–333, 1816.

Allen, Paul, "History of the Expedition under the Command of Captains Lewis and Clark," etc., 1814, reprint by New Amsterdam Book Company.

ton. Meriwether lost his father early in life, and one of his uncles acted as his guardian. At the age of thirteen he was sent to the Latin school, where he remained until he was eighteen, when he returned home to help run the farm. At the age of twenty he entered as a volunteer a body of militia which was called out by General Washington to quell troubles in the western states, and from the militia he entered the regular service as a lieutenant. When twenty-three years old he was promoted to a captaincy and made paymaster of his regiment. He was personally well known to Thomas Jefferson, and when the latter proposed that two persons should be sent up the Missouri River, across the Rockies and down the Columbia to the Pacific Ocean, he eagerly offered to go. A few years later Jefferson, remembering the eagerness of Captain Lewis to make the trip, made him leader of the expedition, which successfully carried out the plans, and is now known as the Lewis and Clark Expedition. Captain Clark was made the leader in the absence of Lewis. The expedition started in 1803 and returned in 1806. Congress gave both leaders grants of land, and Lewis was made governor of the territory of Louisiana, while Clark was made a general of militia and agent for Indian affairs. Upon assuming his duties as governor, Lewis found many factions and parties, but his even-handed justice to all soon established respect for himself, and eventually removed animosities. While on a trip to Washington he suffered a temporary attack of insanity, and committed suicide on October 11, 1809.

Pursh has named a genus of the Portulacaceæ, *Lewisia,* in his honor.

During the early part of the nineteenth century it was much the fashion for botanists to collect living plants and cultivate them in gardens, these gardens sometimes being quite extensive. Sometimes they were but temporary resting places for the plants until they could be sent to European countries as novelties to be introduced there because of some desirable quality. André Michaux had such gardens into which he gathered his plants, and when opportunity offered sent them to France. Many of our early botanists had their own gardens in which they cultivated all of the different plants they could find, and thus became acquainted with every detail concerning them. The Bartram and Marshall gardens near Philadelphia were good examples of these early collections of living plants.

Among many persons sent from Europe to this country for the purpose of collecting new and rare plants was one John Bradbury,[4] who was commissioned to act as the agent of the Liverpool Botanical So-

[4] Bradbury, John, "Travels in the Interior of America in the Years 1809, 1810 and 1811," 1–346, 1819, 2d edition.

Short, C. W., *Transylvania Jour. of Med.*, etc., 34: 12–13, 1836.

Britten, Jas., and Boulger, G. S., "Biographical Index of British and Irish Botanists," 21, 1893.

ciety. Comparatively little seems to be known about Bradbury. He was a Scotchman who had lived for a long time in England, when he received his commission from the Liverpool Botanical Society in 1809. Upon arriving in this country, Bradbury spent several days at the house of Thomas Jefferson, so that the latter became acquainted with him and his abilities. Jefferson spoke highly of him as a naturalist, and Short, a later writer, mentions him as "an English gentleman of very respectable attainments as a naturalist." In the light of our present knowledge he seems to have fully deserved such an estimation, as he discovered a considerable number of new species as well as a new genus of plants during his travels in the Missouri country. Indeed, several of our more characteristic species bear his name, and in later years he was honored by Torrey and Gray, who named a new genus *Bradburia,* in commemoration of his services in exploring our western flora.

Mr. Bradbury at first intended to make New Orleans his center of operations, but following the advice of Jefferson he changed that intention and came to St. Louis instead. He descended the Ohio River by boat, making such observations and collections as he could at the various stopping places, arriving at St. Louis on the last day of the year 1809. The entire season of 1810 was spent about St. Louis, making short excursions of not more than eighty or one hundred miles distance in all directions, and he accumulated a considerable collection of plants which were sent to Liverpool the succeeding autumn. No definite data can now be obtained as to the number of species contained in these collections, as Bradbury never published a complete list of them, although he did give a list of the rare and more interesting plants in his journal, which was published after his return to England.

Early in the spring of 1811 Bradbury, accompanied by a young and zealous botanist named Thomas Nuttall, joined a fur-trading expedition, and with them ascended the Missouri River as far as the Mandan villages, not far from the site of the present town of Bismarck, North Dakota. Upon reaching this point the expedition divided and part of it, including Bradbury, returned to St. Louis. The others went on still farther, and Nuttall remained with them until their return to St. Louis some months later. This voyage was made in a steamer, and progress was necessarily slow while going up the river, so that our naturalists had ample time and opportunity for collecting. A collection even larger than that which had been made around St. Louis is said to have been accumulated.

Before Bradbury had finished his preparations for departure to England, the war of 1812 broke out, and he remained for several years in this country until the close of hostilities. He finally reached Liverpool in 1815, and found that during his long absence his plants had been inspected by Pursh, who was at that time in England preparing the

manuscript for his "Flora Americanæ Septentrionalis." Pursh published the most interesting of these plants in an appendix to his work, and this seems to have discouraged Bradbury from publishing as extensively upon them as he probably would have otherwise done. In 1817 Bradbury published his journal of travels on the Missouri in the years 1809–10–11, and in an appendix to this gave a list of the rare and most interesting plants of his collections. He did not, however, issue a complete list, and so far as now known no such list has ever been published. The second edition of his travels was issued in 1819, and in the editor's preface it is stated that Mr. Bradbury had already returned to St. Louis and taken up his residence there. Baldwin, who passed through St. Louis in 1819 with the Long expedition, mentions meeting Mr. Bradbury there at that time. His name is given in the St. Louis city directory for 1821,[5] but no definite information regarding him after this date has yet been found.

During the early part of the nineteenth century it was the policy of the national government to send expeditions of a military character to explore the unknown sections of the western country. Shortly after Bradbury made his tour of the Missouri, an expedition was fitted out and placed under the command of Major S. H. Long. This was intended to make more complete and detailed exploration of the Missouri and its main tributaries, and to make more accurate scientific observations of the country passed through. The necessity of having competent scientific men accompany the expedition was recognized, and several such men were appointed for the purpose.

The botanist of the expedition was Dr. William Baldwin.[6] He was a son of a minister of the Friends in Pennsylvania, being born in Newlin, Chester County, in 1779. He studied medicine at the University of Pennsylvania and took his degree in 1807. Meanwhile he had become interested in the study of botany, and upon settling in Wilmington, Delaware, to commerce practising his profession, he collected extensively in the vicinity. Pulmonary weakness forced him to remove to Georgia in 1811, where he served as surgeon to a gunboat flotilla during the war of 1812. He kept up his collecting and study of the plants of this new region, and because of his ability as a botanist he received an appointment as surgeon to the U. S. frigate *Congress,* during a cruise to various South American ports. Baldwin made extensive collections and notes wherever opportunity offered, and he returned with a

[5] Learned by the aid of the St. Louis Historical Society.

[6] Thwaites, R. G., "Early Western Travels," Vol. 14.
Darlington, William, "Reliquiæ Baldwinianæ," 1–346, 1843.
Redfield, John, *Bot. Gaz.*, 8: 233–237, 1883.
Harshberger, J. W., "Botanists of Philadelphia," 119–125, 1899.

very considerable amount of valuable material. About this time the Long expedition was being organized, and Baldwin was recommended to act as botanist for the party. His health was delicate and the appointment was accepted in the hopes that it would be improved by the journey.

Baldwin joined the other members of the scientific staff at Pittsburg and embarked upon the steamer which was to take the expedition to Council Bluffs. This being the early days of steamboating, the one used by the expedition gave more than ordinary trouble and caused

FIG. 2. DR. WILLIAM BALDWIN; from Darlington's "Reliquiæ Baldwinianæ."

vexatious delays. According to the letters of Baldwin it also leaked continually, and this made the interior damp and totally unsuited for such a prolonged voyage. Baldwin's health constantly grew worse, and even while descending the Ohio River the party halted to allow him to recover from an attack of illness, and he was forced to depend upon the others to bring specimens to him on the boat, as he had not sufficient strength to walk any considerable distance. St. Louis was finally reached on June 9 and a stop of several days was made. The voyage

was resumed on the twenty-first, and on July 13 they reached Franklin, then the uppermost town of any importance on the Missouri. Here Baldwin was left behind at the house of Dr. Lowry, where he remained until his death on August 31. During his stay in Franklin Baldwin botanized as much as his limited strength would permit, and entries were made in his diary as late as August 8, the date of the last entry. A list of plants found around Franklin by him during this time attests the earnestness with which he pursued his beloved science. The journals of the expedition show that he collected about one hundred species in the vicinity of St. Louis and on the Missouri to Franklin.

His companions all unite in praise of his devotion to science and his persistence under such extremely trying circumstances. Notwithstanding his extensive travels and his earnest study of the botany of several different sections of this country and of South America, he published but little. Two short articles, presented for publication just before starting with the expedition, are all that are known to have been published by him. He left numerous manuscripts and notes which have aided Torrey and Gray in their work on the flora of America. His herbarium was extensive and very valuable, and has contributed much to the works of Pursh and Nuttall. Baldwin also contributed to Muhlenberg's catalogue, and he maintained an active correspondence with many of the foremost botanists of his day. Nuttall has honored him by naming a genus of the Compositæ *Baldwiniana,* and has thus connected him in a most permanent manner with that science to which he so earnestly devoted himself.

The Long expedition proceeded and on September 17 went into winter quarters near Council Bluffs. Major Long meanwhile went east, and on his return brought with him Dr. Edwin James, who had been appointed to take the place of Dr. Baldwin.

Edwin James[7] was born in Weybridge, Vermont, on August 27, 1797. Edwin was the youngest son of Deacon Daniel James, who was a native of Rhode Island, and had moved to Vermont at the beginning of the Revolution. In youth he was very industrious and applied himself to his studies with perseverance. His education was obtained at the district school, and later he attended Middlebury College, where he graduated in 1816. Subsequently he studied medicine with his elder brother in Albany, New York, for three years. During this time he became interested in botany and the natural sciences, which were then being taught by Professor Amos Eaton. Upon the recommendations of Captain Lewis Le Conte and Dr. John Torrey he was appointed to the place left vacant by the death of Dr. Baldwin. The trip with Major

[7] Thwaites, R. G., "Early Western Travels," Vol. 15.
Parry, C. C., *Amer. Jour. Sci. and Arts,* 2d series, 33: 428–430, 1862.
Sargent, C. S., "Silva of North America," 2: 96, 1891.

Long was a hurried one, although it was made overland from St. Louis to Council Bluffs and but few plants were collected near St. Louis. James remained with the expedition until its close. His efficient labors are proved by the subsequent publications founded upon his observations and collections. The present Pikes Peak was first named James's Peak, by Major Long, but for some unexplained reason the earlier name has not remained in use.

The next two years after the return of the expedition were spent in compiling his results, which were published in 1825, and were of much historical and scientific value. During the next six or seven years he served as a surgeon in the regular army at extreme frontier posts, and here he studied the Indian languages and translated the New Testament into the Ojibwe tongue. He also published a biography of John Tanner, a man who was captured by the Indians while a child, and was brought up by them. When the medical department of the army was reorganized he resigned and returned to Albany, where he was associate editor of a temperance periodical. Upon leaving this he went west and settled near Burlington, Iowa, where he spent the last days of his life in agricultural pursuits. On October 25, 1861, he was run over by a wagon and injured so seriously that he died three days later.

The genus *Jamesia,* of the Saxifrage family, was named in his honor by Torrey and Gray.

The results of the exploring expeditions seem to have directed attention to the Missouri country, so that a number of men of ability came to that section and made botanical explorations of greater or less extent. Before the Long expedition had finished its work an amateur botanist, Dr. Lewis C. Beck, was collecting about St. Louis.

Dr. Lewis Caleb Beck[8] was born in Schenectady, New York, on October 4, 1798. In 1817 he graduated at Union College; he then studied medicine and began to practise at Schenectady in 1818. He moved to St. Louis in 1820 and lived here until 1822. During this time he collected quite extensively and later published a list of his collections. His introductory note is self-explanatory and is as follows:

> During my residence in Missouri, in the years 1820, 1821 and 1822, a portion of my time was occupied in the investigation of the vegetable productions of that and the adjoining state. Upon my return I was so fortunate as to receive, uninjured, the collections which I had made.
>
> Until the present season (1826), however, I have not had leisure to examine them with the necessary attention, and to revise my notes upon the recent plants. This work I have now commenced, and submit to you the first part,

[8] Appleton's "Cyclopedia of American Biography," 1: 213, 1887.
Anonymous, *Amer. Jour. Sci. and Arts,* 2d series, 16: 149, 1853.
March, Dr. Alden, Gross's "Amer. Med. Biography," 679–696, 1861.
Beck, L. C., *Amer. Jour. Sci. and Arts,* 10: 257–264, 1826; 11: 167–182, 1827; 14: 112–121, 1828.

for publication in your valuable journal. Those species which are presented as new are minutely described, and in all cases where the western specimens of known plants differ from the eastern, this difference is stated. By this means we shall become acquainted with, at least, some of the peculiarities in the vegetation of that interesting section of the United States. Concerning the more common plants, the habitats and times of flowering only are mentioned. The catalogue, it is hoped will contribute somewhat to increase our stock of knowledge, and will be particularly interesting to geographical botanists, and to future writers upon the botany of the United States.

This annotated list, which was continued in three volumes of *Silliman's Journal,* mentions about two hundred species of plants, and is the earliest extensive list known to the writer. Many of Beck's plants are cited in Riddell's "Synopsis of the Flora of the Western States," published in 1835, but apparently only a portion of them are so mentioned.

In 1822 Beck moved back to Albany and remained there the rest of his life. He held positions as professor of botany and other sciences at a number of institutions up to the time of his death; Rensselaer Polytechnic Institute, Rutgers College and Albany Medical College being those with which he was most prominently connected. Dr. Beck was well known in botanical circles, being the author of a manual of the botany of the northern and middle states, of which two editions were issued. He also published a number of botanical papers. He was a well-known writer on chemical and medical subjects besides; and published a manual of chemistry which passed through four editions. He seems to have been a conservative writer, as his bibliography contains but twenty-three titles. Dr. Beck died at Albany on April 20, 1853.

After Beck closed his work in the vicinity of St. Louis there seems to have been a period of nearly ten years when there was no botanical work done. In 1831, however, there began a period of activity which has continued more or less regularly up to the present time. The first botanist to start this activity was Thomas Drummond.

(To be continued)

THE APPLICATION OF ZOOLOGICAL LAWS TO MAN[1]

By Professor WILLIAM RIDGEWAY, M.A., F.B.A., Litt.D., LL.D.

THIRTY years ago in this very city I heard for the first time a presidential address at the British Association, and I was singularly fortunate in entering on my novitiate. I had the privilege of hearing Professor Huxley deliver his presidential address to the embryo of that section over which I, a very unworthy successor, have this day the honor to preside. On that occasion Huxley dealt almost exclusively with the physical evolution of man, and the Neanderthal skull played an important part in his discourse. The anthropologists of that day and since have severely criticized, and rightly so, the old teleological doctrine that everything except man himself had been created for man's use, and they emphatically enunciated the doctrine that man himself has been evolved under the same laws as every other animal. Yet the anthropologists themselves have not always carried out in practise their own principles to their logical conclusions. To-day I shall attempt to show that the chief errors which impede the scientific study of man, which lead to the maladministration of alien races, and which beget blunders of the gravest issue in our own social legislation, are due in the main to man's pride in shutting his eyes to the fact that he is controlled by the same laws as the rest of the animal kingdom.

I. Let us first consider some of the chief problems which at present are being debated by the physical anthropologists. Foremost in importance of these is the stratification of populations in Europe. It has generally been held as an article of faith that Europe was first peopled by a non-Aryan race. Of course it is impossible for us to say what were the physical characteristics of paleolithic man, but when we come to neolithic man the problem becomes less hopeless. It has been generally held that the first neolithic men in Europe, whether they were descended or not from their paleolithic predecessors, had long skulls, but were not Aryan; that later on a migration of short-skulled people from Asia passed along central Europe and into France, becoming what is commonly termed the Alpine, by some the Ligurian, by others the Celtic race; that later these two primitive non-Aryan races were overrun by the Aryans, who, when these theories were first started, were universally considered to have come from the Hindu Kush, but

[1] Address of the president of the Anthropological Section of the British Association for the Advancement of Science, Dublin, 1908.

are now generally believed, as held by Latham, to have originated in upper central Europe. Yet, although the view respecting the cradle of the Aryans has changed, anthropologists have not seen the important bearing that it has upon the problem of neolithic man. The Aryans are generally held to have had a blond complexion.

As our discussion must from its nature concern itself with questions of race, let us first examine the criteria by which anthropologists distinguish one race from another. If you ask an anthropologist how he distinguishes an Aryan from a non-Aryan race, he will tell you that he relies on three main tests: (*a*) the color of the skin, hair and eyes; (*b*) the shape of the skull and certain other osteological characteristics; and (*c*) the system of descent through males. Formerly language was included in the tests of race, but when it was pointed out that the Negroes of Jamaica speak English, those of Louisiana French, henceforward it was assumed that one race can embrace the language of another with the greatest ease. Yet it may turn out, after all, that language was too hastily expelled from the criteria of race. On the other hand, we may find that too implicit faith has been placed on the three criteria of cranial characteristics, pigmentation and law of succession.

(*a*) As it is assumed that all Aryans were blond and traced descent through males, so it is held that all Europeans, who are dark-complexioned, and whose forefathers traced descent through women, are non-Aryan in race, and that, although they now in almost every case speak an Aryan tongue, this is not their primitive speech, but simply that learned from their Aryan conquerors. According to this orthodox view, the dark-skinned inhabitants of Italy, Spain and Greece are all non-Aryan, and all have borrowed the language of their masters, whilst, of course, the same is held respecting the melanochrous population of France and of the British Isles. Ever since Professor Sergi comprehended under what he terms the "Eurafrican species" all the dark-complexioned peoples of southern and western Europe, as well as the Semitic and Hamitic peoples of western Asia and northern Africa, the doctrine that the dark-skinned peoples of Europe once spoke a non-Aryan tongue or tongues is supposed to have been finally established. But under his Eurafrican species Sergi includes the blond race of northern Europe who speak Aryan languages along with the dark races who speak non-Aryan tongues. It is argued that as all the dark-skinned peoples on the north side of the Mediterranean belong by their physical type to the same original stock as the Semites and Hamites, they must likewise have spoken non-Aryan languages. Yet it might as well be maintained that the Finns, who speak a non-Aryan tongue, and the Scandinavians, who speak an Aryan, were originally all of one stock, because both races are blond.

This doctrine of a Mediterranean race depends upon the tacit assumption made by the physical anthropologists that identity or similarity of type means identity of race. Yet this assumption does not bear the test of scientific examination, for it assumes that only those who are sprung from a common stock can be similar in physical structure and coloration, and it leaves altogether out of sight the effects of environment in changing racial types, and that, too, in no long time. The change in the type of the American of New England from that of his English ancestor and his approximation to the hatchet face and thin scraggy beard of the Red Indian have long been remarked, whilst the Boers of South Africa, in less than 150 years, have quite lost the old Dutch build, and become a tall weedy race. The effects of climatic conditions are very patent amongst the native peoples of the New World. The Iroquois of the temperate parts (lat. 40°–45°) of North America were a tall, rather light-complexioned race, but as we keep moving south and approach the equator, their kindred tribes grow somewhat darker in complexion and more feeble in physique, except where they live at a considerable altitude, for of course altitude acts in the same way as latitude. When once we pass below the equator the physique keeps steadily improving until we come to the Pampas Indians, a vigorous race who defied all the efforts of the Spaniards to subdue them; and finally we meet the Patagonians (lat. 40°–53°), a fine, tall, light-complexioned race, who form in the south the counterpart of the Iroquois and their closely allied tribes in the north.

The same law, as is well known, can be seen at work in Europe. Starting from the Mediterranean, we meet in the lower parts a melanochrous race; but gradually, as we advance upwards, the population as a whole is growing less dark, until finally, along the shores of the Baltic, we meet the tallest and most light-complexioned race in the world. Of course it has been explained that the change in pigmentation, as we advance from south to north, is due to the varying proportions in the admixture of the blond race of the north with the melanochrous of the south. But it is difficult to believe that the movements up or down of the people from the southern side of the Alps, or of those from the shores of the Baltic, have been so nicely proportioned as to give the general steady change from north to south in coloration without the aid of some other force. The case of America, which I have just cited, is in itself enough to raise a suspicion that climatic influences are at work all the time, and that environment is in reality the chief factor in the variation of both stature and pigmentation from the Mediterranean to the Baltic. The white race of the north is of the same proximate ancestry as the dark-complexioned peoples of the northern shores of the Mediterranean. I have already argued elsewhere that, as the ice-sheet receded, mankind kept pressing farther

north, and gradually under changed climatic conditions the type changed from area to area, and they all still continued to speak the same Indo-European tongue, but with dialectic variations, these also being no doubt due to the physical changes in the vocal organs produced by environment.

If we turn from man to the other animals we find a complete demonstration of this doctrine. For instance, the conditions which have produced a blond race on the Baltic have probably produced the white hare, white bears, and the tendency in the stoat and the ptarmigan to turn white in winter, whilst in the same regions of Europe and Asia the indigenous horses were of a dun color, who not only turned white in winter, but had a great tendency to turn white altogether. It may be objected that the Lapps and Eskimo are not tall and blond, but, on the contrary, short and dark; but they live within the arctic circle in regions where the sun does not shine at all for a great part of the year, and consequently they are quite outside the conditions of environment under which the tall blond race of North Germany has long dwelt. Of course, in dealing with man we are always confronted with the difficulties arising from his migrations; but if we can find a family of lower animals who can not be said to have thus migrated, and who show the effects of environment, we shall be able to argue powerfully from analogy.

The horse family supplies the example required. If we follow it from northern Asia to the Cape of Good Hope, we shall find that every belt has its own particular type, changes in osteology as well as in coloration taking place from region to region. First we meet the old dun horse, with its tendency to become white, the best European examples of which were probably the now extinct ponies of the Lofoden Isles. In Asia, Prejvalsky's horse is the best living instance—a dun-colored animal with little trace of stripes. Bordering on the Prejvalsky horse, or true tarpan, come the Asiatic asses: first the dzeggetai of Mongolia, a fawn-colored animal, the under parts being Isabella-colored; then comes the kiang of the Upper Indus Valley, seldom found at a lower altitude than 10,000 feet, rufous brown with white under parts, whilst, as might be expected from its mountain habitat, its hind quarters are much more developed in length and strength than in the asses of the plains. The *Onager indicus, onager* and *hemippus* are found in all the great plains of the Punjab, Afghanistan, western India, Baluchistan, Persia and Syria, whilst a few are said to survive in South Arabia. All these are lighter in color than the kiang, the typical onager being a white animal with yellow blotches on the side, neck and head. All the Asiatic asses are distinguished by the absence of any shoulder stripe, though they occasionally show traces of stripes on the lower parts of the legs. The southern Asiatic asses just de-

scribed in their grayer color and smaller hoofs approximate to the wild asses of Africa, especially to those of Somaliland, whilst it is maintained that in their cry, as well as in their color, the kiang and dzeggetai come closer to the horse, whose next neighbors they are.

Passing to Africa, we find the ass of Nubia and Abyssinia showing a shoulder stripe, and frequently with very strongly defined narrow stripes on the legs, the ears being longer than those of the onager. But in closer proximity to southwestern Asia comes the Somali ass, which differs from those of Nubia and Abyssinia by being grayer in color, by the entire absence of shoulder stripes and by smaller ears, in all which characteristics it comes closer to its neighbors on the Asiatic side than it does to its relations in Abyssinia and Nubia.

Next we meet the zebras. First comes the magnificent Grévy zebra of Somaliland, Shoa and British East Africa. It is completely striped down to its hoofs, but the coloration of the specimens from Shoa differs from that of those from Somaliland, and from those of British East Africa. The Grévy zebra has its hoofs rounded in front like those of a horse, but its ears are more like its neighbors, the asses, than those of any other zebra.

In the region north of the river Tana the Burchelline group of zebras overlaps the Grévy, and though it differs essentially in form, habits and shape of its hoofs from the Grévy, some of those in the neighborhood of Lake Barringo show gridiron markings on the croup like those on the Grévy zebra, whilst, like the latter, they also possess functional premolars.

All the zebras of the equatorial regions are striped to the hoofs, but when we reach the Transvaal, the Burchelline zebra, known as Chapman's, is divesting itself of stripes on its legs, whilst the ground color is getting less white and the stripes less black. Farther south the true Burchell zebra of the Orange River has completely lost the stripes on its legs and under surface, its general coloring being a pale yellowish brown, the stripes being dark brown or nearly black. South of the Orange River the now extinct quagga of Cape Colony had not only begun to lose the stripes of its under part and on the hind quarters, but in Daniell's specimen they only survived on the neck as far as the withers, the animal having its upper surface bay and a tail like that of a horse, whilst all specimens of quagga show a rounded hoof like that of a horse.

In the quagga of 30°–32° S. we have practically a bay horse corresponding to the bay Libyan horse of lat. 30°–32° N.

But the production of such variations in color do not require great differences in latitude. On the contrary, from a study of a series of skins of zebras shot for me in British East Africa, each of which is from a known locality and from a known altitude, there can be no

doubt that such variations in color are found from district to district within a comparatively small area.

In addition to the two species of zebra already mentioned, there is the mountain zebra, formerly extremely common in the mountainous parts of Cape Colony and Natal, though now nearly extinct in that area. Its hind legs, as might naturally have been expected from its habitat, are more developed than those of the other zebras, just as these same limbs are also more developed in the kiang of the Himalayas than in any other ass.

With these facts before us, there can be no doubt that environment is a most potent factor not only in coloration, but also in osteology. No less certain is it that environment is capable of producing changes in animal types with great rapidity. Thus, although it is an historical fact that there were no horses in Java in 1346, and it is known that the ponies now there are descended from those brought in by the Arabs, yet within five centuries there has arisen a race of ponies (often striped) some of which are not more than two feet high. Darwin himself has given other examples of the rapid change in structure of horses when transferred from one environment to another, as, for instance, when Pampas horses are brought up into the Andes.

Another good example is that of the now familiar Basuto ponies. Up to 1846 the Basutos did not possess a single horse, those of them who went down and worked for the Boers of the Orange River usually taking their pay in cattle. At the date mentioned some of them began to take horses instead. These horses were of the ordinary mixed colonial kinds, and we may be sure that the Boers did not let the Basutos have picked specimens. The Basutos turned these horses out on their mountains, where, living under perfectly natural conditions, their posterity within less than forty years had settled down into a well-defined type of mountain pony.

Nor is it only in the horse family that we meet with examples of the force of environment. The tiger extends from the Indian Ocean, through China up to Corea, but the tiger of Corea is a very different animal from that of Bengal. Instead of the short hair of the Indian tiger the Corean has clothed himself with a robe of dense long fur to withstand the rigors of the north. It is not unlikely that if we had a sufficient number of skins from known localities we could trace the change in the tiger from latitude to latitude, just as I have shown in the case of the Equidæ.

Now whilst there is certainly a general physical type common to all the peoples round the Mediterranean, it by no means follows that all those peoples are from the same original stock. On the contrary, the analogy from man in other parts of the world, as well as that of the Equidæ, suggests that the resemblance between the Berbers, who speak

Hamitic, the Greeks, who speak Aryan, and the Jews and Arabs, who spoke Semitic, is simply due to the fact that those peoples, from having long dwelt under practically similar conditions in the Mediterranean basin, have gradually acquired that physical similarity which has led Sergi to the assumption that they have a proximate common ancestry, and that they accordingly form but a single race.

Nor is there any lack of instances of convergence of type under similar conditions in the case of the lower animals. We saw that the asses of southwestern Asia approximate in color to the asses of northeast Africa, and in respect of the size of the ears and absence of shoulder stripe, more especially to the nearest of these, the ass of Somaliland. Yet it does not follow that they are more closely related to the Somali ass than they are to their own next neighbors, the kiang. On the contrary, it is much more likely that the Somali ass is closely related to those of Abyssinia, and that the southwestern Asiatic asses are closely related to the kiang. The approximation in color, absence of shoulder stripe and size of the ears between the asses of Somaliland and those of southwestern Asia must rather be explained by a convergence of types under the somewhat similar climatic conditions of Somaliland and the nearest parts of southwestern Asia. Again, though there are very strong, specific differences between the Grévy and Burchelline zebras met in the neighborhood of Lake Barringo, there is a curious approximation, not only in marking, but also in the teeth between these two species, which is best accounted for by supposing that it is the outcome of similar environment. It may be said that this approximation may be due to the interbreeding of the two species of zebras in the region where they overlap. This, in itself a most unlikely contingency from all that is known of the habits of wild species, certainly can not be alleged in the case of the convergence in type between the asses of southwestern Asia and the Somali ass, since they are separated by the Red Sea and the Persian Gulf.

Again, the representative of the crocodile family in the Ganges is distinguished by the extreme elongation of the head and jaws, whilst the same elongation of the head is equally characteristic of the representative of the dolphin family found in the same waters. Again, all through the Indian Ocean wherever any family of crabs have become inhabitants of coralline sands its members have long legs. Again, it has long been noticed that in Cutch all the larger animals have a tendency to become a sandy color, whilst in certain areas of South America insects, no matter to what family they belong, have a tendency to one common aspect.

It may, of course, be said that the changes in color of the horse family, tigers and insects are for "protective" reasons. But the case of the horse family alone is sufficient to dispose of this objection.

The kiang of the Himalaya had no dangerous enemy until man was armed with a rifle. In Africa the zebras have had only two formidable foes—man and the lion. It is asserted by the most experienced hunters that the gaudy livery of the zebra makes him conspicuous from afar, whether he is on the mountain, on the plain or in the shade of a tree. His brilliant color, therefore, really exposes him to man. But it will be said that it is well adapted to conceal him at night, at which time the lion seeks his prey. Yet as the best authorities hold that the lion hunts entirely by scent, the coloration of the zebra affords him no protection against his inveterate foe.

I have shown that in horses the colors—such as bay, black, gray and white—accompany certain well-defined inward qualities. But as black is most certainly not a primitive horse color, it follows that coat colors may be intimately connected with certain other characteristics quite irrespective of protective coloring. Again, as the variation in the size and shape of the ears and hoofs of the asses and zebras can not be set down to protective coloring, but must be due to other causes, there is no reason why variations in color should not be ascribed to similar causes.

The argument based on the analogy of the horse family and the tigers, and on that of the natives of the New World, may be applied to the races of Africa. Next to the Mediterranean lie the Berbers and their Hamitic congeners, who are regarded as part of the Eurafrican species by Sergi and his school. But the Berbers are not all of the typical Mediterranean physique. The blond Berbers of the highlands of Rif in Northwest Morocco and of the Atlas have long been well known. In the region lower down and in western Tunis the occurrence of the xanthochrous type seems much less frequent, whilst farther east it practically disappears.

It is certain that there was a fair-haired element in Libya long before Rome conquered Carthage or the Vandals had passed into the ken of history. Callimachus testifies to the existence of blond Berbers in the third century B.C. We may hold, then, with Sergi and others that the blond element in the Berbers is not a survival from invasions of Vandals or Goths, or from Roman colonists, but that they rather owe their fair complexions and light-colored eyes to the circumstance that they were cradled in a cool mountainous region, and not along the low-lying border of the Mediterranean like their dark-colored relations whose language and customs they share.

If, then, some of those who speak Hamitic are fair, and have been fair for centuries before Christ, as Sergi himself admits, whilst others are dark, there is no reason why some of the peoples who speak Aryan might not be dark whilst others are blond.

The Berbers and their Hamitic congeners shade off on the south

into other peoples, but this is not altogether due to intermarriage, as is commonly held, for it is more probably to be explained as due in a large part to climatic conditions. The Bantus, who are said to have originated in the Galla country and to have spread thence, are now regarded by the chief authorities as the result of an intermixture of Hamites and Negroes. But, on the grounds I have already stated, it is more rational to regard them as having been evolved in the area lying between the Hamitic peoples on the north and the Negroes on the south, just as we have corresponding types of the horse family in Nubia and Abyssinia and in the equatorial regions. The same hypothesis also explains the existence of those cattle-keeping tribes which lie west of the Nile, stretching across northern Nigeria, who border on the Berbers, but yet differ from them, and border also on the Negroes, but differ from them likewise. South of these tribes come the Negroes, the true children of the equator. The Bantu is able to live in elevated equatorial areas, and he has burst his way down to the subtropical and temperate parts of South Africa, where he especially flourishes in the highlands, thus showing that his race was originally evolved under similar conditions. The Bantu found in the south the Hottentots, who are especially distinguished by steatopygy, a feature which has led some to identify them with the primitive steatopygous race supposed to have once lived in southern Europe, Malta and North Africa, and to have left evidence of their characteristic in their representations of themselves. But, granting that such a race once lived in North Africa and southern Europe, there is really no more reason for supposing that they and the Hottentots formed one and the same race than there is for assuming that Daniel's quagga, which was practically a bay horse, was proximately akin to the bay horse of North Africa. The occurrence of steatopygy in two areas so wide apart is not due to an ethnical migration, but rather to similar climatic conditions producing similar characteristics.

As some anthropologists so commonly explain the origin of races such as the Bantus by intermarriage, it may be well to see whether intermarriage between two races, one of which is an invader, is likely to produce a permanent effect upon the general physique of a whole community. I have shown elsewhere that the many invasions of fair-haired races into the three southern peninsulas of Europe and into the Ægean islands have left no permanent trace on the population. It is a matter of common knowledge that the offspring of British and native parents in India have a constant tendency to die out. The same undoubtedly holds true for the offspring of British soldiers serving in Egypt, the Soudan and West Africa. The native race always reasserts itself. In America the Spanish blood has died out, or is dying out, everywhere except in the temperate regions of Chile, Quito and Argen-

tina, where the descendants of the Spanish settlers thrive in a climate very analogous to that of Spain. In the southern states of North America the whites can not flourish, and only just manage to survive. On the other hand, the descendants of the Negro slaves imported into Brazil, the West Indies and the southern states of North America thrive and multiply with extraordinary vigor; a fact doubtless due to their race having been evolved under similar conditions in equatorial Africa.

Even from the evidence already to hand there is high probability that intermarriage can do little to form a new race unless the parents on both sides are of races evolved in similar environments.

I have already pointed out that although the fair-haired race of upper Europe has age after age kept pouring over the Alps into Italy and the other southern peninsulas, and has constantly intermixed with the indigenous populations, it is only in the upper part of Italy that the blond race is able to hold its own. In Italy the xanthochrous race in ancient times, as to-day, had its maximum along the Alps, and gradually dwindled towards the south until the melanochrous race stood practically alone in the lower part of the peninsula. So too in the Balkan, whilst the fair-haired element was at its maximum along the Alps and the Danube, southwards the melanochrous becomes more and more completely dominant, as it practically is to-day in the lower part of the peninsula.

(*b*) In the Alpine regions there has been from Neolithic times a brachycephalic race, also found in central France and in the British Isles, whither it is supposed to have come in the Bronze age. It has been a fundamental article of faith with Sergi and others that this round-headed race came from Asia, the home of brachycephalism. It is Mongolian according to most, and spoke a non-Aryan language; but Sergi regards it as Aryan, thus reverting to the old doctrine, which made the Aryans come from central Asia, and he assumes that these invaders imposed their language both on the aborigines of Italy, such as the Ligurians, and on the blond race of northern Europe; but we shall soon see that this assumption has no base. Now, as these folk dwelt in the region where we find the Ligurians of historical times, others have argued that the Ligurians were a non-Aryan people from Asia. But it is impossible to find any hard-and-fast lines between the Alpine race and the peoples north and south of it in culture and sociology. For that reason, when treating of the people of the Alps in my "Early Age of Greece" I did not take any account of the difference in cranial measurements. In 1906, at the British Association, I maintained that this difference of skull type did not mean any racial difference, and on the analogy of the changes in the osteology of the Equidæ I urged that the roundness of the skulls was simply due

to environment, as the horses of the Pampas when brought up into the mountainous regions of Chile and Peru rapidly change their physical type. Physical anthropologists have already maintained that the round head of the Mongolian has been developed in the high altitude of the Altai. If that be so, there is no reason why a similar phenomenon should not have taken place in the Alpine region, in Albania, Anatolia and wherever else in mountain areas brachycephaly has been found in more than sporadic examples, which, of course, may well be due to migrations or importation of slaves. But I am far from suggesting that altitude is the only cause of brachycephaly.

The evidence, then, as far as it goes, points to the same conclusion as that to which we came as regards pigmentation, and it may eventually be proved that just as each area has its own type of coloration, so also has it its own osteological character. In support of this I may point out that recently Dr. William Wright, Hunterian lecturer, has come to the conclusion from his craniological investigations that the brachycephalic Alpine race was evolved on European soil, whilst Dr. C. S. Myers has been led by his researches on Egyptian skulls to conclude that, " in spite of the various infiltrations of foreign blood in the past, modern Egypt contains a homogeneous population which gradually shifts its average character as we proceed southwards from the shores of the Mediterranean to Nubia beyond the First Cataract."

It is not impossible that Alpine environment may have acted upon the shape of the skull of the ox as well as that of man. We know from the examination of the fauna of the lake dwellings of Switzerland that the Celtic ox (*Bos longifrons*) was there the common type, and its descendants still continue to be the typical breed along the Alpine chain. This ox is characterized by its strongly developed occipital region and its small horns curved forward and inward. As it differs so essentially from the urus (*Bos primigenius*) and from the long-horned cattle of the Mediterranean lands, it seems not unlikely that the peculiar cranial formation may have been evolved under mountainous environment.

It is now clear that differences in the shape of the skull and in the color of the skin, hair and eyes can not be at all implicitly relied on as criteria of race. The defenders of the non-Aryan character of the dark races of Greece, Italy, Spain, France and the British Isles have now to depend on two arguments only, one of which is linguistic, the other sociological. It is admitted that it is very difficult to point to any non-Aryan survivals in the vocabularies of the languages of these countries, and it is also admitted that in them all the tense system of the Aryans has been taken over in its entirety. Neither Kretschmer nor any ore else has ventured to affirm that there is any survival of non-Aryan syntactical forms in Greek, the language of all others in

which the Ayran tense system is found in its greatest delicacy and perfection. But we know that in all cases where an Aryan language has without doubt been adopted by a non-Aryan folk the tense system is invariably broken up. No better example than this is needed than ordinary "pigeon" English. So difficult is it for the defenders of the non-Aryan theory of the origin of the aborigines of Greece to maintain their position that one of the latest, Professor Burrows, has to rely on certain supposed syntactical survivals of a non-Aryan language which Sir John Rhys believes that he has found in Welsh and Irish, and in the remarkable resemblance which Professor Morris Jones thinks that he has traced between the syntax of those languages and that of Berber and ancient Egyptian.

Yet when we examine the evidence on which Sir John Rhys relies, it turns out to be only three Welsh and Cornish oghams, written not in pure Celtic, but in dog Latin, and also two Irish oghams, which show a looseness in the use of the genitive suffix at a time when final syllables were dropping out of use in Irish. Sir John Rhys supposes that the non-Aryan inhabitants of these islands derived their Gaelic speech from a people whom he terms Celticans, who spoke Goidelic, and who were followed by the Brythons, who found the aborigines already Celticized. Professor Morris Jones freely admits that the aborigines must have borrowed the full Aryan tense system, a fact in itself sufficient, from what I have already said, to arouse grave suspicions as to the validity of any arguments based on supposed fundamental grammatical differences. But this supposed taking over of the full Aryan tense system by the non-Aryan aborigines of these islands is rendered all the more miraculous from the circumstance that Sir John Rhys holds that his Celticans, who spoke Goidelic, "came over not later than the great movements which took place in the Celtic world of the continent in the sixth and fifth centuries before our era," that the Brythons "came over to Britain between the time of Pytheas and that of Julius Cæsar," and that the Brythons were not likely to come into contact on any large scale with the aborigines "before they had been to a considerable extent Celticized." It is thus assumed that it was possible for the aborigines to have been so completely Celticized as to have adopted the Aryan tense system, as well as the Aryan vocabulary, in its fullness in the interval between the sixth or fifth century and the second century B.C. Yet English has been the master speech in Britain for many centuries, and that, too, when reading and writing have been commonly practised; yet Gaelic still survives, whilst Welsh not only survives but flourishes. It is, therefore, simply incredible that such a complete transformation as that postulated could have taken place in three or four centuries in an age when writing and literature can be hardly said to have existed in these islands.

Let us now see under what conditions does one race or people borrow the language of another. Slaves, of course, take over the language of their masters, but we have to consider (1) the adoption by a conquering people of the language of the conquered, (2) the adoption by a conquered people of that of their conquerors, and (3) the adoption by a people themselves unconquered of the language of their neighbors. Under what conditions do the conquerors adopt the language of the conquered? Ireland affords us at least two certain examples. Cromwell planted large bodies of his English soldiers in Tipperary, but they had no English women, and therefore took as wives the daughters of the land, who spoke the Irish language. From this union resulted a splendid offspring, who spoke chiefly the language of their Irish mothers, and not their fathers' English. So it came to pass that in a single generation the progeny of Cromwell's Puritans were in language as Irish as the purest-blooded aboriginal of Munster. Yet this adoption of the Irish language by the great majority of the children of these settlers took place in spite of the effect which the reading of books in English must have exerted to counteract the tendency to adopt the Irish language. Let us go back five hundred years in Irish history and we find exactly the same process going on. The Normans who followed Strongbow into Ireland, like their captain, frequently married native women. It is a matter of common knowledge that the Anglo-Norman settlers in a short time became *Hiberniores ipsis Hibernis.*

These and other examples too numerous to cite here prove that the children of bodies of conquerors who marry the women of the land will have an inevitable tendency to follow their mothers' speech. We may also lay down as a solid factor in the tendency of the conqueror to merge into the conquered the isolation of the conquerors from their original homes and from the great mass of those who speak the same language.

Next we come to the case where the conquerors bring with them some women of their own race. This of course helps to keep their own language alive, as a certain number of the children speak it as their mothers' tongue. But even in these circumstances the invaders are liable to drop their own language and practically adopt that of the natives. Thus the Northmen who settled on the coast of France gradually abandoned their national tongue for French, though modifying dialectically their adopted language. When under the name of Normans they conquered and settled in England, they again adopted the language of the conquered, though modifying the English tongue by many words and phrases brought with them from Normandy, and we have just seen how some of their descendants who settled in Ireland for the third time changed their speech for that of the conquered.

Hitherto all our examples show the adoption by the conquerors of

the language of the conquered, even when they bring a certain number of their women with them.

We now come to undoubted cases where the language of the conqueror has been able to get a firm foothold. From the time of the plantation of Ulster, the advance of the English tongue, and consequent decadence of the Irish, has steadily proceeded, for the settlers, unlike Cromwell's Ironsides, brought with them women of their own race and speech. Consequently their children grew up speaking English as their mothers' tongue. Yet even with such a basis the advance of English amongst the Irish has been exceedingly slow. In the glens of Antrim the Irish language still lingers on, whilst in Donegal, Connaught, Kerry, Cork and Waterford, English has not succeeded in ousting completely the native language, though the former is the language of the national schools, of the newspapers and of trade.

The story of the establishment of English itself in Britain is just the same as in Ulster. We know from Bede that the Angles who settled in Britain left Holstein in large bodies, bringing with them their wives and families, and leaving their old homes without inhabitant. Having thus settled in solid masses in the east of Britain, they retained fully their own tongue, impressed it upon their menials, and gradually, as they extended their conquests westward over the island, English became the language of the land. Yet in Wales the ancient speech still flourishes.

We may, therefore, conclude that the adoption by the conquered of the language of the conqueror, even when it does take place, which is but rarely, is a very slow and tedious process, although every advantage is on the side of the invading tongue, and that when the native speech gets a fair field, as in Wales, the language of the conqueror can make little or no advance.

Only the third possibility now is left—that one people can adopt without conquest the language of another. But no example of such can anywhere be found, although Europe presents numerous instances to the contrary. There can be no stronger case than that of the Swiss Republic, in which peoples with more than four kinds of language combine for national defense and other advantages. Here, if anywhere, we ought to find a gradual adoption by certain cantons of the language of their neighbors. But, far from this being so, the German, French, Roumansch and Italian cantons rigidly preserve their respective mother-speeches. In the Austro-Hungarian Empire there is no tendency observable on the part of either Magyars or Slavs to adopt German; nay, the very opposite is the case. Again, the Finns have not adopted either Swedish or Russian, though partitioned between their more powerful neighbors.

To sum up, it seems that no nation readily adopts the language of

another, even though it be in close ties of friendship; whilst there is still less tendency when national hostility intervenes. Secondly, the adoption of the language of the conqueror by the conquered, except under the most favorable circumstances, is not common, and only takes place by a very gradual process, as is seen in the case of Ireland. Thirdly, there is a strong tendency for the conqueror to adopt the language of the conquered, as was done by the Normans in England, In Ireland, in Sicily and in Italy; by the Cromwellian settlers in Tipperary, by the Bulgari in Bulgaria, by the Franks in Gaul, by the Lombards in Italy and by the Visigoths in Spain. There is thus an inevitable tendency for the children to speak their mothers' tongue, and indeed the phrase "mother-tongue" is based on the fact observed through long ages that the child learns its first words from its mother and thus takes after her in speech. This law, which still holds good in modern days and in civilized communities, must have been far stronger in earlier times in countries where the tie of marriage hardly existed and the child belonged to its mother's and not its father's tribe, as is still the case in many parts of the world.

In view of these facts we can not accept Sir John Rhys's hypothesis that when a few bodies of invaders, whom he terms Celticans, passed into Ireland the indigenous supposed non-Aryan race within two centuries completely abandoned its own language, taking over in its entirety the Aryan tense system as well as the Aryan vocabulary of its conquerors.

Now let us turn to Greece, Italy and Spain. It is admitted that neither Arcadia nor Attica was ever conquered by Acheans or Dorians, yet in both these areas the Greek language existed through all historical time, and in Attica especially the Aryan tense system is found in its highest perfection. The dialect of Arcadia can not have been taken over from Acheans or Dorians, because it is the same as that of the Cypriotes from Arcadia who settled in Cyprus at least 1100 B.C. It is also very close to the dialect of Pelasgiotis in Thessaly, the home of the aboriginal Pelasgian population, whilst it comes closest of all Greek dialects to that of the ancient Epic. There can, therefore, be no doubt that Arcadian is no mere bastard lingo, half non-Aryan, half Aryan, but is the genuine speech of the oldest and most unmixed population of Greece, who were undoubtedly a melanochrous race, and who also most certainly had occupied Greece from the Stone age.

The Ligurians, who formed from the Stone age the bottom stratum in all upper and central Italy, are now admitted to have spoken an Aryan language, and I have recently given some reasons for believing that the Latin language is simply the native tongue of the aboriginal Ligurian population of Latium with some admixtures derived from the Italic tribes of Siculi and Sabines. I have also shown that the ancient

Iberians, the next neighbors of the Ligurians, used the same forms of place-names as the latter, and that some of the words plainly exhibit Aryan terminations. Thus we may conclude that with the exception of the Basques, who are probably a non-Aryan spurt from North Africa, the melanochrous populations of Spain, Italy, the Balkan Peninsula, France, Britain, Ireland and Holland have from the first spoken none but an Aryan language.

(*c*) Only one argument is now left to the defenders of the non-Aryan theory. When the study of sociology first sprang up in the last century, it at once became a fundamental doctrine that the Aryans had always been strictly patriarchal, and that polyandry and descent through women was unknown amongst them. Though this view has received many rude shocks in later days, Professor Zimmer argues from it that the indigenous people of Britain and Ireland were non-Aryan.

It is well known from the ancient writers that the Picts were polyandrous and that succession was consequently through females. Again, it is certain, both from the ancient Irish literature and also from statements of external writers, that the Irish were polyandrous, and that they also almost certainly traced descent through women. Accordingly, Professor Zimmer infers that the indigenous race was non-Aryan. But McLennan has long since pointed out that descent through women was the ancient law at Athens, and I have just shown that the Athenians and Arcadians, the autochthonous, dark-complexioned people of Greece, never spoke any save an Aryan tongue. Moreover, I have shown elsewhere that the Ligurians, who are now generally admitted to have spoken always an Aryan language, had descent through women, whilst I have also pointed out that there is good evidence that the ancient Latins, who have generally been taken as typical Aryans, had the same system. Again, it is admitted that the ancient Illyrians and dark-complexioned Thracians spoke an Aryan language, which, inasmuch as it differed materially in certain ways from that spoken by their Celtic overlords, must have been aboriginal, whilst I have further given grounds for believing that the ancient Iberians (though not the Basques) were also an Aryan-speaking folk. But there is good evidence that the Illyrians, melanochrous Thracians and Iberians all traced descent through women. In view of these facts it is useless to urge that because the Picts of Scotland and the ancient Irish had that system of succession through females these peoples must have been non-Aryan.

We have now reviewed the three main criteria of race at present used by anthropologists: (*a*) pigmentation of the skin, hair and eyes; (*b*) the shape of the skull and other osteological characteristics; and finally, (*c*) their system of tracing descent. We have seen that osteological differences may be but foundations of sand, because it is certain

that such variations take place within very short periods, not only in the case of the lower animals, as in the horse family, but in man himself. Pigmentation is no true criterion, for we have found a steady tendency to change in color in the case of the lower animals from latitude to latitude, whilst in the case of man the steady shading off in color from dark to blond may be traced from the equator to the Baltic. Unless, then, we postulate that man is entirely free from the natural laws which condition the osteology and pigmentation of other animals, we must admit that neither bone nor color differences can be regarded as crucial criteria. Further, we saw that the test of descent through males or females broke down absolutely in the case of peoples who can be proved historically never to have spoken any but a non-Aryan language. Finally, we are forced to the conclusion that language, now that we realize what are the laws which govern its borrowing by one race from another, is really the surest of all the known tests of race when dealt with broadly and over wide areas, and not merely in the way of guesswork etymologies.

II. Hitherto I have dealt only with the need of a rigid application of zoological laws in studying the evolution of the various races of man. In the time that is still left I propose to touch briefly on the vast importance of such natural laws when dealing with the native races of our great dependencies and colonies, and in our own social legislation. I venture to think that the gravest mistakes which at present are being made in our administration and legislation are due to the total disregard of the natural laws, which not only modify and differentiate one race from another, but also are constantly producing variations within our own community. As physical characteristics are in the main the result of environment, social institutions and religious ideas are no less the product of that environment. Several of our most distinguished Indian and colonial administrators have pointed out that most of the mistakes made by British officials are due to their ignorance of the habits and customs of the natives. It has been in the past an axiom of British politicians that in the English Constitution and in English law there is a panacea for every political and social difficulty in any race under the sun. Only let us give, it is urged, this or that state a representative parliamentary system and trial by jury and all will go well. The fundamental error in this doctrine is the assumption that a political and legal system evolved during many centuries amongst a people of northwestern Europe, largely Teutonic, and that, too, living not on the mainland but on an island, can be applied cut and dried to a people evolved during countless generations in tropical or subtropical regions, with social institutions and religious ideas widely different from those of even South Europeans, and still more so from those of northern Europe. We might just as well ask the Ethiopian to

change his skin as to change radically his social and religious ideas. It has been shown by experience that Christianity can make but little headway amongst many peoples in Africa or Asia, where, on the other hand, Muhammadanism has made and is steadily making progress, acting distinctly for good, as in Africa, by putting down human sacrifice and replacing fetish worship by a lofty monotheism. This is probably due to the fact that Muhammadanism is a religion evolved amongst a Semitic people who live in latitudes bordering on the aboriginal races of Africa and Asia, and that it is far more akin in its social ideas to those of the Negro or Malay than are those of Christianity, more especially of that form of Christianity evolved during the last twelve centuries by the Teutonic peoples of upper Europe, who are of all races farthest in physical characteristics, in religious ideals and social institutions, from the dark races of Africa and Asia. This great gulf is due not merely to shallow prejudice against other people's notions; it is as deep-seated as is the physical antipathy felt by the Teuton for the Negro, which is itself due to the very different climatic conditions under which both races have been evolved. The Teuton does not freely blend with the black, and even when he does intermarry he treats his own half-bred progeny with contempt, or at most with toleration. On the other hand, some south Europeans—for example, the Portuguese—are said to have little objection to intermarrying with dark races and allowing the mixed progeny an equal social status, whilst the Arab through the ages has freely taken to wife the African, and has never hesitated to treat the hybrid offspring as equals. There is thus a wide breach between the physique and the social and religious ideas of the African and our own; but, as political and legal institutions are indissolubly bound up with social and religious, it follows inevitably that the political and legal institutions of a race cradled in northern Europe are exceedingly ill adapted for the children of the equator. Accordingly, in any wise administration of these regions it must be a primary object to study the native institutions, to modify and elevate them whenever it may be possible, but never to seek to eradicate and supplant them. Any attempt to do so will be but vain, for these institutions are as much part of the land as are its climate, its soil, its fauna and its flora. "Naturam expellas furca, tamen usque recurret." Let us hope for a successful issue for the effort now being made by the Royal Anthropological Institute to establish an Imperial Bureau of Anthropology whose function will be not only to carry out systematically the scientific study of man, but also to aid the administrator and the legislator, the merchant and the missionary.

III. I now pass to my last and most important topic—natural laws in relation to our own social legislation. We have seen that environment is a powerful factor in the differentiation of the various races of

man, alike in physique, institutions and religion. It is probable that the food-supply at hand in each region may be an important element in these variations, whilst the nature of the food and drink preferred there may itself be due in no small degree to climatic conditions. Each zone has its own peculiar products, and beyond doubt the natives of each region differ in their tastes for food and drink. The aboriginal of the tropics is distinctly a vegetarian, whilst the Eskimo within the arctic circle is practically wholly carnivorous. In each case the taste is almost certainly due to the necessities of their environment, for the man in the arctic regions could not survive without an abundance of animal fat. It is probable that the more northward man advanced the more carnivorous he became in order to support the rigors of the northern climate. The same holds equally true in the case of drink. Temperance reforms would enforce by legislation complete abstinence from all alcoholic liquors, and they point to the sobriety of the Spaniards, Italians and other South Europeans, and urge, if these nations are so temperate, why should Britons and Irish continue to drink beer and spirits in such large quantities? This appeal depends, unfortunately, on the false assumption that the natives of these islands enjoy the same climate as the people of the sunny south. All across northern Europe and Asia there is a universal love of strong drink, which is not the mere outcome of vicious desires, but of climatic law. In Shakespeare's time "your Englishman was most potent in potting," and this was no new outbreak of depravity, for the earliest reference in history to the natives of these islands tells the same tale. When Pytheas of Marseilles traveled in these regions, about 350 B.C., he found the people making "wine from barley," and, though he does not explicitly say so, we need not doubt that it was meant for home consumption. In view of these facts we must regard this tendency as essentially climatic. This view derives additional support from the well-authenticated fact that one of the chief characteristics of the descendants of British settlers in Australia is their strong teetotalism. This can not be set down to their having a higher moral standard than their ancestors, but rather, as in the case of Spaniards and Italians, to the circumstance that they live in a country much warmer and drier than the British Isles. We must, therefore, no matter how reluctantly, come to the conclusion that no attempt to eradicate this tendency to alcohol in these latitudes can be successful, for the most that can be done by the philanthropist and the legislator is to modify and control it, but especially by moral means.

I have spoken of the principles at work in the differentiation of one race from another. It may be that the same principles or others closely allied may be at work within each community, for each community is but the whole world writ small. Within the United King-

dom itself there are not only different physical types, but very different ideas respecting marriage and divorce embodied in the laws regulating those fundamental institutions in England, Scotland and Ireland. If such fundamental differences exist in that most important of social institutions, we may well expect that the natural laws which differentiate one race from another may be at work within every community in the United Kingdom.

Yet though the world has been ringing with the doctrine of natural selection and the survival of the fittest for nearly half a century, no statesman ever dreams of taking these great principles into consideration when devising any scheme of education or social reform. On the contrary, it is a fundamental assumption in all our educational and social reforms that all men are born with equal capacities; that there is no difference in this respect between the average child of the laborer, sprung from many generations of laborers, and one born of many generations of middle- or upper-class progenitors; and it is held that all that is necessary to make the children of the working classes equal, if not superior, to the children of the bourgeois is the same food, the same clothing and the same educational advantages. On that account we have devised the so-called educational ladder. Yet if we ask any social reformer why are there middle classes, the answer will probably be that they are better off. But why are they better off? We are told that their fathers and mothers were better off, and that they thus got a better chance than the poor laborer. But why were the parents of these middle-class folks better off? Oh! they came of families that had been long well-to-do. But why were these families long well-to-do? At last we are brought to the conclusion of the northern farmer, that "Work mun 'a' gone to the gittin' whiniver munny was got," and to his brutal correlative respecting the laborers that "Them or thir feythers, tha sees, mun 'a' beän a laäzy lot."

Work no doubt has been a main factor in the evolution of the middle and upper classes, especially in later times, though undoubtedly other qualities, such as superior physique and superior courage, have been very important elements in the earlier stages. But at all times it is not improbable that the special quality which led to their rise was a superior self-restraint, that enabled them to resist the vices which are too often attendant on prosperity. This superior morale acts in turn upon the offspring by setting up a better standard of life in the home, which of itself gives children brought up in such an environment an advantage at the outset of life denied to the children of inferior parents. It needs no elaborate induction to prove that the middle classes are not the outcome of chance, but of a long process of natural selection and the survival of the fittest in the struggle for life, the two main factors in this evolution being, in the language of Aristotle, heredity and

training. Each community is but a microcosm of the whole human race, which, as I have endeavored to show, is bound by the same laws as the rest of the animal kingdom. One race becomes a master because of its superior physique, courage, brain power and morale; another sinks in the struggle or lags behind owing to its inferiority in the very qualities which have given the mastery to its rival. What is true of master races in relation to inferior races is equally true of the individuals in each community. The middle and upper classes are in the main sprung from ancestors with better physique, courage and morale, and who have generation after generation been brought up in a better moral atmosphere than the children of the masses. Their ranks are also continually being reinforced by the best of the working classes. But this is not due to any educational ladder provided in modern times, for the process has always been at work, though of course its action has been distinctly aided by modern legislation. Medieval history supplies many examples of those who, though sprung from the humblest parents, rose to high place in church and state. This was not due to any legislative enactments, but rather to a principle well known in the whole field of nature. Every one knows that the superior varieties of flowers and vegetables are commonly the "sports," as they are termed, from inferior species. The skillful gardener watches carefully for good "sports," for they may become very valuable additions to his *répertoire* of useful plants. So, too, the legislator must watch carefully for good human "sports," not for those with criminal propensities. In the medieval world the church provided a ladder by which the son of the peasant could rise to be the counsellor of kings and princes. In modern times the state provides an educational ladder by which the child of the humblest parents may rise, if it has the capacity, to the highest positions in the community. It is right—nay, essential—that such a ladder should be provided, but this ladder is not for the mass of children. The vast majority can never climb beyond its lowest rung, owing to their heredity, and in a less degree to their home environment. The ladder is for the good "sports," who by its aid are thus continually reinforcing with fresh blood the ranks of the middle and upper classes.

It may be said that I underrate the number of the good "sports." Of course it is very difficult to get any exact statistics on so complex a subject; but according to information which I have obtained from one of our great industrial centers, where the educational ladder enables any child who passes the fourth standard in the primary schools before it is eleven to rise into the secondary schools, it is probable that no more than 5 or 6 per cent. of the children of the working classes have at the age of sixteen the same amount of brain power as the average children of the middle classes at the same age. But even all this 5 or 6 per cent. of "sports" can not be credited to parents of the working class

alone, for it may be that a certain proportion of them must be ascribed to middle- or upper-class parents. Of course these rude statistics must be corrected by others collected on a large scale all over the country before we can form a final judgment; but I believe that the evidence already to hand makes it improbable that more than a very limited percentage of the children of the working classes have the same ability as the average child of the middle classes.

In ancient days the chief end of the legislator was to produce a stalwart brood of citizens capable of bearing arms in defense of their country and advancing her material prosperity. Still more ought this to be the aim of our legislators to-day, for under modern conditions great masses of population are huddled together in a manner hardly known to ancient cities. To accomplish this great end, the legislator must not merely look to improved housing of the poor and the development of the physique of city populations. He must, as far as possible, conform to the principles of the stock-breeder, whose object is to rear the finest horses, cattle or sheep. Amongst wild animals nature selects the fittest for continuing the race, and the wise breeder simply aids nature by selecting still more carefully the best animals. The legislator, on his part, ought similarly to foster the increase of the best element in the state, and on the other hand discourage the multiplication of the worst. Yet in our community statesmen of both parties have adopted the very opposite policy. The children of the working classes are educated at the cost of the state, the offspring of the wastrels are given free meals, and already there are demands that they shall be clothed at the expense of the ratepayers, and that the parents shall even be paid for providing them with lodging. It is not impossible that before long these demands will be conceded by either party in the state. The heavy additional expense incurred in this policy falls upon the middle-class ratepayers and taxpayers, who have to feed, educate and clothe their own children at their own expense. It may be said that they can get free education for their children by sending them to the state schools; but this is to level down instead of to level up; for if they do so they will be lowering the general morale of their own class, the most priceless asset of the nation. The heavy burden of taxation entailed by this policy, falling as it does with special weight on the middle classes, renders it more difficult each year for the young men and the young women in that class to marry before thirty, for they naturally shrink from the expense of bringing up large or even moderate-sized families. We need not, then, wonder at the falling off in the rate of increase of the middle classes. Our legislators are bad stockmasters, for they are selecting to continue the race the most unfit physically and morally, whilst they discourage more and more the increase of what we have proved to be the outcome of a long process

of natural selection. The present policy, therefore, tends to reduce that which in all ages has been the mainstay of every state, the middle class. The yoemen of England, the free burghers of Germany and of Italy, formed the best element in the Middle Ages. So was it also with the great republics of the ancient world. Aristotle, in more than one passage, has pointed out that the middle class, that which stands between the "excessively wealthy" and the "very poor," between the "millionaire" and the "wastrel," are the mainstay of every state, and he shows that, where the middle class has been crushed out by the millionaire or the mob, ruin has inevitably overtaken the state. Indeed, it is clear that the chief defect in the Greek democracies was the smallness and weakness of the middle class, whilst it is notorious that Rome prospered only as long as the middle-class citizens flourished. Her downfall came when they were extinguished by the great capitalists, who made common cause with the masses against them. The latter had no patriotism, were incapable of bearing arms, and had no aspirations beyond free meals and popular entertainments at the expense of the state.

It is of great scientific interest to discover how the short-skulled peoples of Asia and Europe became differentiated from their long-skulled congeners; it is of great practical importance to apply to the administration of our great dependencies and colonies the lessons taught by anthropology; but it is infinitely more important to maintain a vigorous stock of citizens for the kingdom and the empire. Questions of the origin of races are, after all, only academic; but the other two, more especially the last, are intimately bound up with the life of the nation. If the present policy of our legislators is adhered to, the moral and the physical standard of the British citizen will steadily deteriorate, for the population will gradually come to consist of the posterity of those who are themselves sprung from many generations of the most unfit. Should this unfortunately come to pass, it will be the result of human pride refusing to apply to the human race the laws which inexorably regulate all nature.

CANADIAN WHEAT

By Professor JOHN WADDELL
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FOR twenty years the Canadian government has been carrying on experiments in wheat growing under the supervision of the director of the Experimental Farm at Ottawa, Dr. William Saunders.

The United States leads the world in the production of wheat; Canada's growth is only one ninth as large, her export to Great Britain during the years 1901–3 was slightly less than one fifth, though in 1905 it was somewhat more than one half. The year 1905 was very abnormal, however. The United States export to Britain was exceedingly low and was surpassed by those of Russia, Argentina and India. But Canada's growth of wheat, though much less, is greater in proportion to her population, and in view of the many millions to be fed in the United States, it seems natural that before long Canada will export a greater quantity than she. Considering the circumstances, this is as natural as that America's output of coal and trade in iron should be the greatest in the world.

But the greater part of the Canadian wheat area is north of the forty-ninth parallel of latitude and so Dr. Saunders has experimented in growing wheat as far north as possible. The climate in America is colder than at the corresponding latitude in Europe, and so far, at least, we have no records of wheat being grown in Canada as far north as in Russia, but a near approach has been made. Winnipeg's latitude is 50°, and wheat has been grown at Dunvegan on the Peace River, on a parallel of latitude 414 miles north of Winnipeg; at Fort Vermillion, farther down the Peace River, 591 miles by latitude north of Winnipeg, and at Fort Simpson on the Mackenzie, 818 miles north. The latitude of Fort Simpson is approximately sixty-two degrees or within five degrees of the Arctic circle. The length of the summer days compensates for a lower temperature, and the time of ripening of some of the earlier grains is practically the same as in Ottawa. At Fort Simpson 107 days were required as compared with 106 days in Ottawa, some sixteen degrees farther south. Sixteen degrees south of Ottawa is New Orleans. Among the first experiments were comparisons of different varieties of wheat and these experiments are still carried on continually. Some varieties, probably by far the greater number, are cultivated for a season or two only, because they prove to be worthless,

but many are sown year after year. These experiments are carried on not only at the central station at Ottawa, but at other stations as well, chiefly in the northwest. Plots one fortieth of an acre in size are found most convenient for the preliminary tests. When varieties are tested for productiveness the condition of ground and cultivation and seeding are made uniform and it has been found that productiveness is in a large degree persistent. Thirty-one varieties of wheat were grown year after year for five years, and of these a select list of the best twelve was made each year. It was found that there were only sixteen varieties that entered this list during the five years, the varieties that were superior in one year being for the most part superior always. Productiveness is, of course, an important consideration, for, other things being equal, an additional bushel per acre means an annual increase of four million dollars with Canada's present wheat acreage, and a correspondingly larger increase as more land is brought under cultivation.

Red Fife is the standard variety of wheat in Canada. It was imported in 1842 by Mr. David Fife, of Otonabee, Ontario, and was part of a cargo brought from Danzig on the Baltic, to Glasgow, and there transshipped to Canada. Dr. Saunders found that during the nearly fifty years that Red Fife had been cultivated there had been no deterioration, the quantity and quality of crop were as good as ever and in the northwest appeared even to improve. But it is rather later in ripening than is desirable where frosts set in early, and one of the great objects aimed at has been to cultivate a variety having the good qualities of Red Fife and at the same time maturing earlier. If also increased productiveness, quality of grain, strength of straw, or ability to resist rust could be attained, so much the better. The value of early ripening is evident when one realizes that two or three weeks' gain in this respect enables a variety to be grown several hundred miles farther north.

One of Dr. Saunders's first measures was to import varieties from all parts of the world where wheat was grown and to test their development under the new conditions. The United States, Japan, Australia, Russia, and even India, contributed many varieties. It was fortunate that the collection was so world wide, for the unexpected happened. It was found that several varieties from India were among the earliest. This proved to be because they were grown in the Himalayas. Thereupon special attention was paid to India, and at a height of 11,000 feet a variety was obtained, the Gehun, that has since been the subject of much experiment. This, along with the Ladoga variety, obtained from the district surrounding the lake of that name, and the Onega variety, from near Archangel, has proved the most promising of

the early wheats imported and thus an altitude of eleven thousand feet in a latitude of twenty-five or thirty degrees offsets a northern latitude of sixty or sixty-five degrees at a low level.

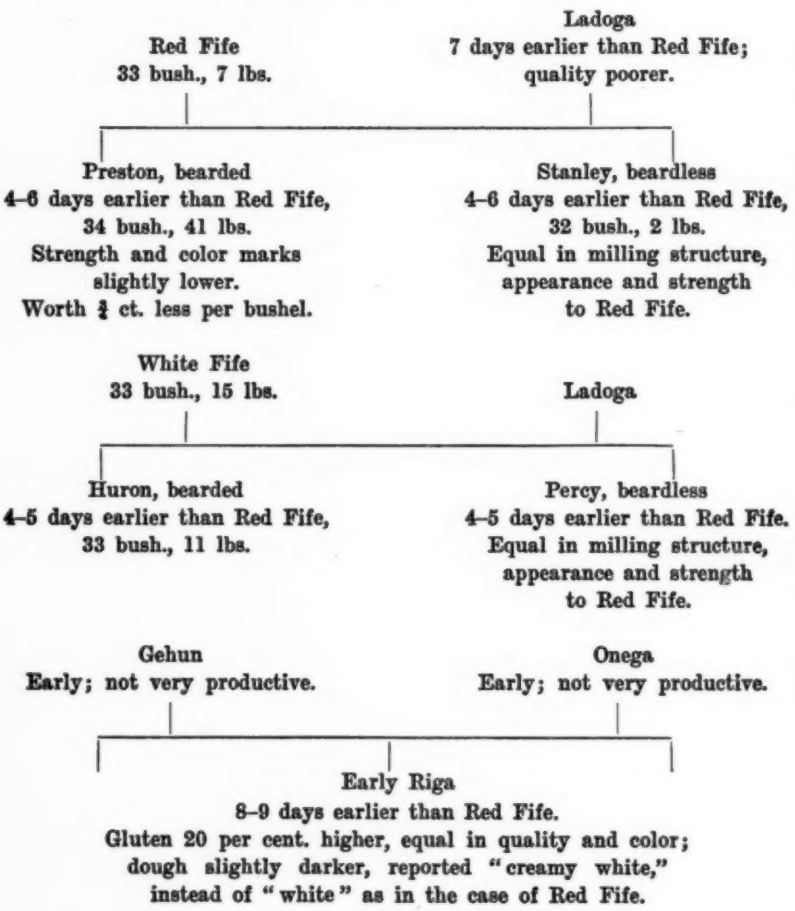
New varieties have been obtained by selection and cultivation of natural variations, but a new era was begun on July 19, 1888, when the first experiments were undertaken in the cross-breeding of wheat on the Experimental Farm, and since that time several hundred new sorts have been produced and tested. None of the imported varieties which mature earlier than Red Fife were found to equal it in quality, and in originating the new productions by cross-fertilization Red Fife has in the majority of cases been one of the parents. Ladoga is about a week earlier than Red Fife and is fairly productive, and numerous crosses were made between the two. The most promising of the offspring were carefully cultivated and subjected to rigid inspection, all less desirable sorts being promptly discarded, and the better ones multiplied till seed was obtained for large plots. Of the progeny from this cross, perhaps the most satisfactory and promising are the Preston, a bearded variety, and the Stanley, beardless. These varieties are twin. They originated from one kernel. The heads produced the first season from this kernel were all bearded, but when the seeds from these heads were sown the year following, some plants produced bearded heads and some beardless, and afterwards each variation was cultivated until the type became fixed. The Stanley is from four to six days earlier than Red Fife, is equal to it in milling structure, appearance and strength, but a nine years' comparison shows that on the average it is less productive, its yield being 32 bushels, 2 pounds, against 33 bushels, 7 pounds, in the case of Red Fife. The Preston is as early as the Stanley, is more productive than Red Fife, but is of a slightly lower grade, worth in the London Corn Exchange about three quarters of a cent per bushel less. The value per acre is higher than in the case of Stanley or Red Fife.

Ladoga has also been crossed with White Fife, a variety slightly more productive than Red Fife. The most valuable of the progeny are Huron, which is bearded, is early and is slightly more productive than Red Fife; and Percy, also early, equal to Red Fife in quality, but even less productive than Stanley, yielding as a nine years' average about one hundred pounds less wheat per acre than the standard Red Fife.

Neither Gehun nor Onega is very productive, but, as before stated, they are both early and of their progeny Early Riga ripens eight or nine days earlier than Red Fife. Its productiveness is more than two bushels per acre lower than Red Fife, but its content of gluten—the most important constituent of wheat—is higher. I quote Dr. Saunders's words:

The reports on the Early Riga wheat are most gratifying. The proportion of gluten found in this variety is about twenty per cent. more than in Red Fife and the quality of gluten equal. To find a wheat superior in quality to Red Fife is what one would scarcely expect; but to find that superiority associated with so much earliness—from eight to nine days as an average of five years' trial—is highly satisfactory. The general introduction of such a wheat will probably extend the wheat-growing area in Canada and make it successful at points farther north than is possible with the varieties at present grown. The fact that it falls a little below Red Fife in yield is more than atoned for by its earliness and quality. The outlook in this connection is most encouraging and the results a triumph of the skill of the plant breeder.

The relation between the very important varieties described may be represented as in the accompanying diagram:


Red Fife
33 bush., 7 lbs.
Ladoga
7 days earlier than Red Fife; quality poorer.
Preston, bearded
4–6 days earlier than Red Fife, 34 bush., 41 lbs.
Strength and color marks slightly lower.
Worth ¾ ct. less per bushel.
Stanley, beardless
4–6 days earlier than Red Fife, 32 bush., 2 lbs.
Equal in milling structure, appearance and strength to Red Fife.
White Fife
33 bush., 15 lbs.
Ladoga
Huron, bearded
4–5 days earlier than Red Fife, 33 bush., 11 lbs.
Percy, beardless
4–5 days earlier than Red Fife.
Equal in milling structure, appearance and strength to Red Fife.
Gehun
Early; not very productive.
Onega
Early; not very productive.
Early Riga
8–9 days earlier than Red Fife.
Gluten 20 per cent. higher, equal in quality and color; dough slightly darker, reported "creamy white," instead of "white" as in the case of Red Fife.

The cultivation of the different varieties was carried on by Dr. Saunders and his assistants, but the value of the product was determined not only by the chemist of the experimental farms, but by one

of the most competent authorities in England and by Mr. Julicher, of Minneapolis, one of America's best known wheat experts.

Though only a few varieties have been specifically mentioned in this article because they have been most thoroughly investigated, yet many others show great promise, some of them maturing two weeks earlier than Red Fife. These will probably prove valuable not only in northern latitudes, but also in cold and damp soils farther south. A variety that proves promising at one station is tested at the others and if it is satisfactory it is grown in plots larger than the experimental, and the very best grain is selected for further experiments.

Until within the last few years experiments on the milling properties and quality of flour of a new variety of wheat could not readily be carried out because small quantities of grain could not well be ground in ordinary flour mills, and several years were needed in order to grow a sufficient amount for testing, but now the use of a small experimental mill and of the necessary baking apparatus enables every new variety to be tested before it is distributed to farmers throughout the country. For experiments have not been confined to the Experimental Farms. After it has been found that a variety proves satisfactory on the small scale and in the special localities under the supervision of the government, the seed is sent out to all farmers applying for it. The first year 1,149 lots were sent out in this way; in 1906 over 45,000 samples, each of five pounds, carefully selected and done up in strong cotton bags. In order to provide this seed, large areas are set apart, chiefly at the stations in the northwest, whence the grain is sent to Ottawa for distribution. The very earliest sorts are sent out so far only to those places where there is good reason to hope that they will be of particular value.

Dr. Saunders calculates that even without including the far northern territories the Canadian northwest could supply not only sufficient wheat for a local population of thirty millions, but have left over three times as much as the total import of the British Isles. This is on the assumption that one fourth of the arable land is devoted to wheat. If the northern lands are made available by the cultivation of very early varieties of wheat it follows that the possibilities of Canada are immense.

Dr. Saunders's work is therefore of the greatest value to Canada and must have an influence on the rest of the world as well.

COLLEGE STANDARDIZATION

By Professor W. LeCONTE STEVENS
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IN war between nations the standardization of armies is universally recognized to be the first essential of efficiency. The function of every leader, every fighter and every carrier is distinctly understood. Likewise in the domestic war of commerce, which is chronic, the organization of great corporations, with division of labor and singling of industrial functions, is the greatest promoter of both production and distribution. In theory the great corporation is a public blessing. In practise its beneficence has been somewhat concentrated, the benefit to the public being only incidental, but loudly proclaimed. The organized corporation receives from the state a charter, intended for the protection of the unorganized public. The corporation is justly held responsible to the state for the performance of the functions specified in its charter and for the avoidance of injustice to the public. The most troublesome problem of our country at present is connected with the enforcement of laws intended to protect the public from the greed of corporations, from false capitalization, from unjust discrimination in rates, from the corruption of legislation by indirect purchase of special privileges. Whether a tariff should be intended for national revenue or for protection to the special interests organized into great corporations is a question the settlement of which is already clear enough, but practically it may perhaps be reserved for a future generation. Whatever may be its settlement, the corporations are here to stay and no return to the simpler conditions of a half century ago can be expected. We are adapting ourselves to present conditions and in time this problem will be solved as others of no less magnitude have been solved by our fathers.

One of the real benefits to the public due to the existence of great corporations has been the development of a general demand for standardization. Everything must be measured that can be bought or sold. The results of work must be numerically compared; new units of measurement must be devised as soon as needed; secondary units must be derived from them; and familiarity with these must be readily attained by the public. Corporations must be compelled to give to the public a correct valuation of properties controlled, of profits earned, of wages paid, of business methods employed. Some corporations, such as national banks, have been for years already subjected to such regula-

tion, with advantage both to themselves and to the public. The enforcement of the laws relating to banks has rarely ever been a hardship except to those that have made themselves unsafe by recklessness. Stockholders and depositors have a right to protection; and this might easily be denied them if the inspection of banks were denied. Such is human nature, that the temptation to dishmonesty is greatly reduced by the consciousness of responsibility and the knowledge that untruthfulness in accounts will be sure to bring its own natural punishment with little delay.

In the work of education the process of standardization is as inevitable as in other great industries, despite the fact that the training of the young is not directly merchantable and that industrial competition is not so conspicuous here as in transportation or manufactures. The American public-school system is an enormous educational industry, divided into as many state corporations as there are states in the union, and with as many subsidiary corporations as there are cities where municipal school systems are supported by local taxation. The growth of this aggregation of school industries since the close of the civil war has been proportioned to our national growth in population. The annual profits can not be expressed in dollars, but the value of the system as a popular investment is manifested by the willingness of the people to pay for the maintenance of such schools. During the twenty years from 1880 to 1900 the population of the United States grew from 50,000,000 to 75,000,000, and the enrolment in schools from 10,000,000 to 15,000,000; in each case an increase of 50 per cent. In the same interval the total estimated property of the country grew from $42,000,000,000 to $94,000,000,000, an increase of 119 per cent.; and the total expenditure for schools from $80,000,000 to $214,000,000, an increase of 162 per cent.

The rate of increase in expenditure for education was thus about one third greater than the rate of increase in wealth. The average expense to each person in the country for the maintenance of schools rose from $1.56 to $3.36. For salaries of teachers and superintendents the outlay rose from $56,000,000 to $137,000,000. A passing comparison may be here made with the amounts paid by the national government to the army of war pensioners; in 1880, $56,000,000; in 1900, $140,000,000. The function of a war pensioner is to teach patriotism, even if he has never been near a battle. His reward has much exceeded that of the teacher who has really earned his salary. There is need for a consistent system of standardization in comparing the value of the war pensioner with that of the teacher.

In most of our country the system of public education is well organized, and through the reports of superintendents every citizen can obtain all the information he wishes regarding school expenditures,

courses of instruction, standards of scholarship, and general efficiency. Each state is supreme in the control of education within its own borders, and there is apparently little danger that public education will be made subject to the interstate commerce law and thus become subject to federal control. Although state organization is not equally thorough in all sections, the actual condition of public education in any selected state can be well ascertained by comparison of the reports required by law from all superintendents. Without the power of federal control the national bureau of education prepares and issues an annual report embodying a large mass of statistical information and discussion on education, most of which is gathered by voluntary contribution or by study of reports from all parts of the world.

When we pass from the domain of public education to that of private schools a change becomes perceptible. In the public schools there is well-defined gradation into primary, grammar and high schools, the high school generally including four years of well-adjusted work. In the private school there is no responsibility to the state, and each school fixes its own standards. There is more elasticity than in the public school, better opportunity for adaptation to individual needs, but less opportunity for an outsider to form a judgment of the pupil's attainments on presentation of a certificate of graduation. Much excellent work is done, but the opportunities for comparison between private schools are limited, and the opportunities for undue claims to excellence are great. These schools must continue so long as the need for unusual personal attention remains, or as parents are disposed to pay for the privilege of social exclusiveness. As they are usually not incorporated institutions, they can not be held responsible to the public for their standards, and are hence free from such inspection as is not specially invited. Some of them advertise largely, and pretentiously assume the name of colleges, institutes or military academies. In many parts of our country this is done apparently in obedience to popular demand, and is an index of the lack of local demand for standardization.

When we begin to consider the vast conglomerate of institutions that are incorporated as colleges, universities and technical schools we enter a region of chaos. If a school applies to a state legislature for a charter of incorporation as a college there is at present no standard generally recognized by legislators to determine what is a college. To most of them it means merely a school controlled by trustees who form a corporate body, and whose liberty must not be limited so long as they obey the existing laws of the state. It is greatly the exception to find in any state a law intended to protect the public from fraudulent colleges. Such a law was passed by New York a dozen or more years ago. Its main features are as follows:

For an institution to be chartered as a college, (1) it must have at

least six professors giving their entire time to college work. (2) It must require for admission not less than four years of high-school work in addition to the preceding full work of the grammar school. (3) It must give a course of four full years before granting its degree. (4) It must have a productive endowment of at least $200,000. This of course excludes the valuation of land, buildings, equipment, tuition fees or special benefactions.

If this law were adopted and enforced in every state of the union it would exclude five-sixths of the institutions now bearing the name of college or university. Whether such a standard is just or unjust is not for these institutions to determine. It depends partly on the standards of the preparatory high schools that are under the control of the state. No institution should be permitted to assume the name of college whose standard of admission is so low as to allow access for students who have not completed the full high-school course of four years. It depends also on the consensus of opinion among the majority of those who are doing college work in the different countries of the civilized world. The standard of admission just set forth is below that required by the universities in England and on the continent of Europe, and above that which has hitherto been possible of attainment in the southern parts of the United States, where the high-school course is often only three years in length. All standards are the results of agreement, either tacit or formulated, and the consensus of opinion among educators in the more densely populated parts of the United States seems to be that the New York law is not unreasonable.

Most institutions that assume the name of college claim that for the average student four years of college work are needed to obtain a degree. But obviously if the starting point is low the ending point must be correspondingly low, since the capacity of the average student is fairly constant. The claim may be made that examination standards are kept high in spite of low entrance requirements, so that only the best students can expect to be graduated, or even to get through safely in the year's work for a given subject. The present writer once entered a college class in mathematics that had sixty members at the opening of the session, of whom sixteen were taking the subject for the second time. At the close of the session he was so fortunate as to be one of only fifteen who were successfully passed. Of the sixteen who were second-year men seven had failed, and of the forty-four first-year men only six had been successful. The standard of attainment was reasonable enough, but the prerequisites for admission had not been so clearly expressed as to give an adequate idea of the ordeal to which the applicant was to be subjected. If three fourths of a class fail, this does not necessarily mean that so large a fraction of its membership is made up of students who have been unfaithful or of less than usual ability. The amount of teaching may have been insufficient, or the discipline too

lax, or the student may have been admitted at his own peril when safeguards ought to have been provided to shield him from certain failure. No guarantee of success can ever be given; but, if he fails, his misfortune ought not to be due to the imposition of a standard that is possible for only the exceptional man unless the subject is one that implies exceptional scholarship. Unnecessary failure is a calamity, and a fairly good student has the right to expect reasonable protection from it. Few institutions, however, venture upon such indiscriminate slaughter of the innocents as is implied in the case just cited. There may, of course, be exceptions, but in the majority of cases the real value of a diploma at the end of four years is quite fairly proportioned to the value of the entrance requirements at the beginning of that period.

The requirement of six professors giving their entire time to college work is one to which probably no exception can be taken by any who have real knowledge of the meaning of such work. A college to be successful must be well organized. Its head must be energetic, tactful, a good judge of men, thoroughly appreciative of high scholarship, a keen detector of efficiency in teaching, and the possessor of exceptional administrative power. Each professor must not only know his own subject, and how to teach it, but must be single-minded in his devotion to the interests of the institution. To devote most of his time, or even any considerable part of it, to the practise of a profession, with teaching thrown in as an incidental, is to ensure the sacrifice of the student's interests. Through the medium of the press he should keep in touch with the public, and especially with the educational and scientific world, but his main work is in connection with his students, and his income should be such as to make outside work unnecessary. So small a number as six of such men is scarcely sufficient to carry on the work of any modern college. If the New York law is objectionable the fault consists in prescribing a number that is too small rather than too large for a minimum.

The assignment of $200,000 as a lower limit for the productive endowment of a college is a very moderate recognition of what is implied in college teaching. With five per cent. as the rate of interest such a college would have but $10,000 as its income aside from students' fees. Assuming one hundred paying students at $100 each, the income is thus raised to $20,000. Of this, three fifths may be allowed for the cost of instruction, the rest being absorbed in the expenses of administration and operation. A salary allowance of but $2,000 is hence left for each of six professors, the president's salary being included in the cost of administration. The ratio of students to professors would be 100 to 6, or nearly 17, a number too large for the best efficiency. For reasons locally deemed satisfactory, many students are usually admitted without the payment of tuition, with no allowance to the professor for

increasing his burden, so that the teaching ratio is raised from 17 to possibly 20 or more.

The Carnegie Foundation for the Advancement of Teaching published, in May, 1908, the teaching ratios of 93 leading American educational institutions, deduced from data furnished by them. For example, this ratio is given for Johns Hopkins as 4.3; Haverford College, 6.5; Harvard, 8.8; Tulane, 9.5; Texas, 14.5; Drake University (Iowa), 25.7. For the 93 institutions the general average is found to be 11.9. Disregarding other considerations, the possible efficiency increases as the teaching ratio decreases. Since each student ordinarily has several subjects of study and thus multiplies the number of persons taught at a given time by each professor, an average of 50 in each class is allowable, this number being often greatly increased for lecture work and diminished for advanced class work. Experience has thus shown that for good college work the average teaching ratio should not much exceed a dozen, though lecture audiences may be limited only by the capacity of the audience room.

There are seven or eight American universities having each an annual income in excess of $1,000,000. Of those which are still willing to retain the more modest name of college considerably more than a dozen have incomes in excess of $100,000, and endowments in excess of $1,000,000. Nevertheless the assignment of $200,000 as a minimum productive endowment would cause the forfeiture of many charters. In early manhood the writer's first teaching in an incorporated institution was in a "university" having a total endowment of $25,000. The connection was brief, and so was the life of the institution. The legislature that granted its charter was more obliging than well informed about educational standards.

A century ago such institutions as Harvard and Yale were almost without endowment and their annual budgets were nearly limited to the income from students' fees. But since the close of the civil war the growth of our country in wealth has produced unprecedented change in standards of all kinds. If the general standard of comfort in life rises with the prosperity of those in whose hands the greater part of the country's wealth is concentrated, the standard of college expenses may be expected to go up in like manner. Gifts have been showered upon institutions with favored surroundings and the ratio of total expenses to total attendance has been steadily rising. The college that has age, history and respectability without endowment is no longer sought by students who are prosperous enough to attend prosperous colleges, and its sad fate is not hard to predict.

With the growth of endowments and the enlarged scale of expenditure in all institutions of learning the student's tuition fee has been steadily becoming a smaller fraction of the cost of instruction given him. He generally pays less than half of what he costs. Every col-

lege student is now the beneficiary of organized charity, and the self-sustaining college is a thing of the past. The larger the number of students the more unprofitable is the work pecuniarily, unless the growth in attendance is accompanied by corresponding increase of endowment to balance the excess of total annual cost over receipts from tuition fees. In ordinary business the condition is reversed; the larger the scale the greater are the profits possible.

From the popular business standpoint the success of a college is more readily measured by its number of students than by the quality of its work. So urgent is the demand for numbers that it is not uncommon to see the need for increased equipment disregarded, the library prevented from growing and remaining stuffed with out-of-date rubbish; and the professors overworked. As soon as the teaching ratio exceeds a dozen the need for increasing the teaching force becomes imperative. This can not be done if the endowment is too small to permit the payment of living salaries to competent assistant professors. The most ready resource is to impose the duty of teaching upon inexperienced young holders of scholarships, or to grant the remission of tuition fees to selected undergraduates on condition that they perform the function of assistants in the laboratory, the library, or the office of the language professor. If the efficiency of these undergraduate assistants were proportionate to their pecuniary needs, or to their willingness to do their best, such procedure might have some justification. These undergraduate names are recorded, both in the register of students and in the faculty list, and on dividing the number of students by this nominally enlarged faculty number the alleged teaching ratio is brought down so as to present the appearance of efficiency. The public is misled and the college made to appear stronger than is warranted by the facts.

If objection is urged against what has just been set forth, the ready reply is that the only way to impress the public and to attract benefactions is to grow rapidly and let the public know it. The resort to cheap labor in employing inexperienced undergraduates for assistants, and including them in calculating the published teaching ratio, is to be regretted; but it is locally deemed a less serious evil than any check in the rate of growth, even if the endowment fund remains stationary. It is urged that this course is necessitated by the sharpness of competition for students; that catalogue statements must be interpreted liberally, because competitors disregard their printed entrance requirements; that many preparatory schools do not give four years of high-school work, and hence the colleges must adapt themselves to this condition. Some school principals reply that they are anxious to give the fourth year of work, but can not retain their pupils because the colleges admit these as special students; and articulation between school and college, though most desirable, is thus impossible. The inevitable

result is loss of confidence, on the part of these schools, in the disposition of college authorities to deal justly or consistently with them. Rapid growth is indeed desirable, but growth of the faculty is quite as important as growth of the student body. If faculty growth is impossible then the standard of admission should be raised, and the severity of examinations increased, until the student body is cut down to such dimensions that an equitable teaching ratio is recovered. This necessity is fundamental. A reputation for thoroughness, for strict accordance between profession and practise, is better than large numbers. The faculty should be limited to trained specialists, and the students naturally expect instruction from teachers of more maturity than can be expected from those who are members of the student body.

There can be no reasonable objection to the employment of student-assistants if their responsibility is limited enough and no use of their names is made by including these in the published list of apparently responsible instructors. To quote from the second annual report of the Carnegie Foundation (p. 18):

> **The instructing staff includes every person giving regular instruction in the institution except undergraduate assistants. These latter manifestly should not be counted in the teaching force even when they give some teaching. They are primarily college students.**

For colleges whose feeding schools are largely compelled to limit themselves to three years of high-school work an abrupt change to the standard of the New York law is very difficult, if not impossible. If honestly carried out, the change necessitates great loss in numbers. The natural resource for aid is to secure a rise of standard in the local high school, which is in no way subordinate to the college and has no representation in its catalogue. A student coming with defective preparation may resort to this school until the full entrance requirements are fulfilled. Many applicants would undoubtedly be lost to the college on account of unwillingness to continue in the high school, but this is the price that has to be paid for standardization. Within a few years there will be improvement for the college, in both numbers and quality, due to the advance of standard. In Virginia the improvement in high schools during the last ten years has been very marked, and their reactive effect on the colleges is distinctly recognizable.

Among the most insidious of the evils in colleges that strive for numbers is the indiscriminate admission of special students, and of students on certificate from so-called accredited high schools which are not subjected to inspection. The theory of accrediting is that the school gives its certificate of graduation only to students who have successfully completed the full period of four years, with final examinations quite equal to the entrance examinations of the best colleges. The student takes examination on all his subjects immediately after study-

ing them, under conditions to which he is accustomed, and not under the harassing stress of a college entrance test. The work of the college examining board is thus greatly reduced, and the responsibility for the student's possible failure is borne by those who have taught him and have deliberately vouched for him. The school is included in a special published list only after careful inspection by the college authorities or by a state official. If its pupils fail to maintain themselves creditably after admission to college the school is dropped from the accredited list, with danger to the principal, who may be displaced on the ground of incompetence if he is the head of a public school. Such displacement has been produced more than once in the northwest. If these conditions are fulfilled there is little ground for complaint, except that the applicant for admission does not take a general review of all his work before entering college, and hence he has forgotten much of what was once studied. On this account the formal entrance examination is estimated to require about a year more of work than entrance by certificate.

But in some parts of our country, notably the southern and southwestern states, inspection of accredited schools is almost unknown. For one college probably an accredited school is merely a school that can furnish students, and admission by certificate serves the convenient purpose of removing responsibility from the college authorities without fixing it anywhere. The president knows his own interests, and avoids expressing adverse criticism if a student admitted is found badly prepared, because the principal may be offended and may advise his pupils to go to another college. The principal of M. Academy finds young *A*, who is a good athlete, determined to quit school and get into some college team. He knows that a certain college is urgently in need of athletes and not exacting about entrance requirements. He gives to *A* a certificate which is accepted on sight, and no questions are asked. The football season is better than usual, but *A* fails in the first examination season and drops out. Nobody is held blameworthy, and M. Academy is encouraged to send more athletes whenever these can be secured. It is not deemed important that four years of solid preparation should be insisted upon, but this would be very acceptable if an entering athlete comes with such an unusual qualification. Even if he has no perceptible preparation he may be admitted as a special student, whose name helps to swell the registry list. One such is known to have entered at the beginning of the baseball season, going off with the team on the day after registration. On his return, when asked what were his subjects of study, the sober reply was, "Latin, economics and academics." Neither the professor of Latin nor of ecenomics ever formed his acquaintance, and the professor of academics could not be found. But all entrance requirements had been fulfilled for admission to spherics, if this name be applied to ball play. The obvious moral is

that no special student should be allowed membership in an athletic team. The mere fact of such membership is presumptive evidence that he is a special fraud.

The criticisms expressed in the present discussion are the outcome of observation, conversation and correspondence extended through a number of years. They are applicable, at least in part, to a variety of institutions, no one of which is here singled out as a special object of attack, either directly or by implication. The facts are well known to many who are engaged in the work of college education, and there is no wish here to individualize. One of the worst causes of their existence has been the all-pervading pressure of intercollegiate athletics. An institution with few professors and many students, which has much ambition for athletic reputation and therefore has admitted athletes with little discrimination, is confronted with an embarrassing choice of alternatives. It is well established that the average scholarship of athletic teams is low. Those who openly contend that a high standard of scholarship is preferable to a high standard of athletics are exposed to the danger of unpopularity among students, and perhaps among others. Unwelcome criticism based on known facts may be deemed inconsiderate or in bad taste, but evils are rarely ever rectified by ignoring them.

About a thousand American institutions of learning are said to have been chartered as colleges, universities and technical schools, or at least permitted to call themselves by such names. There is no hope that fraud will cease to be practised among them, for every one of them is an index of local civilization, and legislatures are generally willing to incorporate colleges whose standards suit their constituencies. But a hopeful road to improvement is found if every legislature can be induced to follow the example of New York, settling by statute the conditions to be fulfilled for the issuance of a charter of incorporation. Every such charter should be granted for a limited period, such as ten years, and all charters should be revoked if the institutions holding them are unable to meet the requirements of the law. The strong institutions would not be affected, and would have no difficulty in securing decennial renewals. Charters now in existence can not legally be affected, but no new applications for charters would be made with the plea that these are intended to meet future expectations rather than present conditions. It is not to be expected that the law for Virginia or California would be the same as for New York or Florida; but the valuable gain would be the establishment of a definite standard in every state of the union, while the usual condition now is that of no standard whatever. The crying evil is false pretense, the assumption of misleading names, the claim to excellences that do not exist.

In contrast with the New York standard may be mentioned a certain "university" in Florida. Its catalogue in 1903 presented a

faculty list of 69. Of the 450 students 6 were in the kindergarten course, 35 in the primary department, 141 in the school of music, 58 in the college of liberal arts—doubtless very liberal—and 210 scattered through other departments of less importance. This fortunate university "received its charter from the Legislature of the State of Florida." Of its faculty "the majority have pursued graduate courses in American or European Universities" and are "Christian men and women"; hence it would be uncharitable to think that good work is not done. In the mathematical courses the work offered includes "osculation, roulettes, Jacobians, gamma functions, various volutions of cubics and quartics, homographic division, reciprocal polars, conic invariants, and covariants."

The national pure food law has lately mitigated the evils of false pretense in the sale of food and drugs. We are in need of similar protection against those who secure charters for universities with kindergarten departments. The chief function of these universities is to nullify the meaning of college degrees.

In the second annual report of the Carnegie Foundation the president, Dr. Pritchett, says (p. 37):

> Some thoroughgoing financial statement of investments, annual receipts and expenditures should be required by law of all chartered institutions. There is the same reason for a college to exhibit in a business-like way its financial history as for any business concern; and every institution should do this as a matter of good faith.

Probably the mere possession of a charter from the state might be considered sufficient reason for the annual rendition of such a report to the state superintendent of education. He would naturally publish a comparative summary for the different institutions thus represented. For the larger institutions the treasurer's report is always printed and is subject to inspection by those who may be specially interested in it. The financial statement is summarized by each treasurer according to his own plan. Probably it might be best for a common plan to be used by all institutions in the same state. Of late years there has been so much criticism of "bought patronage" that it would be wise for each institution to publish the total amount remitted from students' fees without mentioning the name of any beneficiary. The impersonality of such a statement removes all reasonable objection to such publication.

In addition to its financial statement it would perhaps be very desirable that every college should be subject to examination in such matters as the maintenance of its professed standards of admission and graduation. No detailed investigation of this kind would be possible without treading on delicate ground. It has been suggested that this function might be delegated to a state commission; but the intrusion of politics would be a serious danger, probably nullifying the benefits

sought, even if the facts were attainable. In such matters there is probably no resource but the assurance that the reputation of the institution is obliged in time to suffer if its dealings with the public are not what the public wants. If a high standard of admission is professed and violated, students are quick to detect the fact and to circulate their impressions; and no prying is needed to learn what is generally thought to be the truth. They are the most wide awake and relentless critics that the college can have, and they are more efficient than catalogues, bulletins or commissions in determining the public estimate of its character.

No national law for the protection of genuine educational institutions can be secured, because the control of education is not among the political powers delegated to congress by the constitution of the United States. The case in America is quite different from that in Germany, where professors are commissioned by the imperial minister of education. But within the last few years a national agency of great importance has been brought into existence by the organization of the Carnegie Foundation. The Carnegie board has adopted the New York law as an initial aid in classifying the American educational institutions that seek to secure the benefits of the foundation. The granting of retiring pensions to those who have grown old in the work of college teaching is an uplift that benefits the general cause of education quite as much as the individual beneficiaries of the fund. The annual reports and bulletins of this board have been among the most important contributions to educational progress that have ever been published in this country. In a study of the financial status of the professor in America and in Germany the data were secured by which an illuminating comparison is made between about 160 of our leading educational institutions, including at least two thirds of all those to which the name of college, university or technical school is properly applicable. Although the first wish of the donor was that the fund should be limited to institutions that are not under the legal control of church or state, this limitation has been interpreted with the utmost liberality. The fund has been enlarged to include state institutions of high standard. A college, originally sectarian, may retain with its denomination a relation of "traditional friendship and sympathy, but not one of control." About sixty institutions are already on the accepted list, and others are striving to throw aside denominational shackles or to improve up to the standardized requirements. To attain an end by causing competitors to strive for a prize is better than to make them obey what they may deem a repressive law, even if the law is judicious. The Carnegie Foundation is quietly preparing all the states of the union for improvement in their laws about the chartering of colleges, and it is to-day the most effective agency that tends toward college standardization.

ASPECTS OF MODERN BIOLOGY[1]

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DURING the latter part of August, last year, the International Zoological Congress met at Boston. This circumstance was not very widely heralded by the press, nor did it make an impression on the public mind at all comparable to that ordinarily produced by any serious crime. Nevertheless, it was an event of the first importance, this gathering of the zoological forces of all civilized countries to take stock of the progress of the science and exchange fraternal greetings.

To present any summary of the things said and done at that meeting is neither desirable nor possible at the present time; but it may be useful to consider what it all meant—where zoology now stands, and what it stands for.

Most typical, perhaps, of the whole trend of zoological thought was the address of Professor William Bateson, of Cambridge University. It dealt with the subject of genetics; the genesis of things, cells, individuals, species. It told of sequences actually observed rather than contemporaneous facts arranged in rows. The methods advocated were experimental, the range of investigation was the whole field of life.

At the same time, the geneticologist did not refuse to recognize the value of the other methods of research. Said Professor Bateson: "When morphology was a new idea, everything was sacrificed to its pursuit. Physiology, systematics, all were discarded as useless lumber. Let us not repeat that short-sighted mistake. In the wider survey which we are attempting we shall need all these things. If we are to understand rightly the phenomena of specific difference—to take that problem only—we shall be glad of anything that the systematist can tell us, and of many deductions of pure physiology."

The old natural history is having a new birth, with new hopes and aspirations, but with the same unity of interest and of purpose. With the growth of science, specialization was necessary and desirable. Yet as time went on and zoology not only grew apart from botany, but the various branches of zoology seemed to have different languages, it appeared as if a tower of Babel would result. Even the systems of nomenclature for genera and species, ostensibly the same throughout, came to differ appreciably in different departments; and the various

[1] Lecture delivered before the Scientific Society of the University of Colorado, January 20, 1908.

specialists were so segregated that they were scarcely or not aware of the fact. The grouping was sometimes according to classes, orders and families; sometimes according to physiological or morphological aspects of things; but everywhere it seemed that narrowness increased, and that broad conceptions of the Darwinian type were fading away.

The new attitude typified by Professor Bateson not only unifies the branches of zoology, but makes zoology and botany one. Greedy for the results of special research in every department, it yet makes all serve a common end. So far from despising or discouraging the most minute enquiries in limited fields, it gives them all a new purpose and new meaning, as contributory to the philosophy of life, which is, indeed, the sum of all philosophy. We find ourselves at that meeting point of monism and dualism, of synthesis and analysis, where the electric spark of human understanding always has had and always will have its birth.

Professor Forel, of Switzerland, in a recently issued book, has called attention to the difference between mathematical and ordinary reasoning, including in the latter the methods necessarily employed in the biological sciences. In mathematics, we start with certain postulated facts, and given definite methods of procedure, climb up a ladder of argument, each part of which is supported by the one below. An error at any point vitiates the whole piece of work; while, if there is no error, the result is said to be demonstrated beyond dispute. Systems of logic have been constructed in the same manner, and such processes have found great favor with lawyers and theologians whose main purpose has been to support theories rather than ascertain the truth.

In the natural sciences, as in the every-day affairs of life, the method is entirely different. Desiring to determine the state of things at any point in time or space, we converge upon it all the pertinent evidence we can secure, and form a judgment upon the collection. We do not profess to exclude the possibility of error; rarely do we feel so well supplied with facts that others are not welcome. Those of us who have worked long among biological facts have so often made mistakes, or discovered the mistakes of others, that we have become somewhat more humble-minded and less assertive than we used to be. This humility, however, is coupled with a keen sense of the tremendous weight of evidence in favor of certain conclusions. We do not assert that we *must* be right, but we at least demand an equivalent load on the other side of the scales before changing our opinion: a demand not readily comprehended by those to whom our body of facts is invisible.

In Colorado to-day we find existing many millions of individuals of animals and plants, presenting extreme diversities of form, color and size, and distributed in certain particular ways. It is the business of the naturalist to find out the how and why of all this, so far as he can.

Before he attempts to formulate general laws, he must collect his facts, and examine them in detail. He goes out, perhaps, and gathers a flower: let us say the blue flax, *Linum lewisii*. The very name tells him something of its history; it was called *lewisii* in honor of Meriwether Lewis, of the famous Lewis and Clark expedition. It has been known since 1814, and has been collected by many botanists. Turning to the published records, it appears that it has been found as far south as the mountains of Mexico; as far north as Alaska. It does not occur in the eastern part of the continent, north or south. Among the native plants of America it has only one close ally, a smaller plant called *Linum pratense*—we may call it the prairie flax—which occupies open ground east of the Rocky Mountains from British America to Texas and again appears in Arizona.

In Europe and Siberia, however, there are closely similar plants; so like our *Linum lewisii* that for many years our plant was not separated. Furthermore, there are various other species of *Linum* or flax in the Old World, some of them strikingly different from ours. These, some with blue, some with red flowers, are more closely related to one another than to the yellow-flowered flaxes, which have lately been placed in a separate genus.

From all these facts, it is permissible to assume (in the absence of contrary evidence) that the genus *Linum*, in the restricted sense, belongs especially to and probably originated in the temperate regions of the Old World. This opinion is fortified by the discovery of a species (*Linum oligocenicum* Conw.) in European amber of Tertiary age. We imagine, then, the true flaxes originating perhaps in central Europe or Asia, segregating into various distinct species, and finally, perhaps during the Miocene period, invading North America. From the present distribution of the plant, we should naturally infer that it came by way of Bering Strait, not across the Atlantic; and from its slight divergence from the Old World stock we should think of it as a comparatively recent immigrant. The prairie flax, occupying a lesser area, and not so similar to the Old World type, is regarded as an offshoot from Lewis's flax, adapted to life on the prairies, the former occupying the mountains.

Leaving the flax for the moment, our naturalist hunts about and picks up a small shining cylindrical shell known as *Cochlicopa lubrica*. This snail is distributed widely over the continent, from Canada to Alabama, and west to the Pacific coast region. It is very constant in its characters, but in a few states has given rise to a variety or closely allied form of larger size called *morseana*. There are no other American allies.

So far, there is no apparent clue to its history; but when we turn to the eastern hemisphere we find a very different state of affairs. In the

regions surrounding the Mediterranean there are dozens of species of shells of the same general type, while *C. lubrica* itself is widely spread over the whole of Europe. Moreover, this species *lubrica,* so constant with us, is there much more variable, so that nine varieties have been found in the British Islands alone.

The presumption is, then, that the snail, like the flax, is of Old World origin, and represents a comparatively recent invasion from the ancient area of distribution. This is supported by the occurrence of allied but distinct genera in Europe and adjacent regions.

Further investigation reveals hundreds of other cases similar to those of the snail and the flax, and so it becomes more and more probable, finally practically certain, that we owe a considerable part of our fauna and flora to the immigration of animals and plants which has reached nearly their present condition on the other side of the world. We ourselves, of course, belong in this category.

Having arrived at this point of view, the subject must not be dropped, but should be attacked from another side. If America has been overrun by Old World types in comparatively recent times, it should be possible to get some idea of the time of these invasions by examining the fossils of various strata. Unfortunately, the paleontological record is very imperfect, but it yet yields facts of prime importance. We find that certain types, living in Colorado to-day, have lived here with only slight modifications for many thousands, perhaps some millions, of years. Others are totally absent, so far as our information goes, from the older Tertiary strata, but negative evidence of this kind must always be received with reservations. Others, to-day only found in Asia, Africa, Europe or South America, were conspicuous members of the Colorado biota. Here we find facts which throw doubt on some of our previous conclusions. The Equidæ, or horse family, have to-day numerous members in Africa and some in Asia, but none whatever in America. Yet we have evidence from the fossils that there were formerly horses in America, and that they actually evolved on this continent. The disease-carrying tsetse flies are to-day exclusively African and might well be thought a peculiar product of that continent, but a species has turned up in the Colorado Miocene! So with other cases, all tending to show that it is not safe to assume without question that the original center of a group is the region where it is now most abundant and varied. We do not thereupon decide that the evidence from present distribution is valueless; in many more instances it leads to exactly the same conclusions as might be derived from the fossils; but we recognize the importance of supplementing one kind of fact with another, and considering all together when forming conclusions. When using the paleontological evidence, we are struck by the differences between the fossils of successive strata and are always

inclined to regard these as indicating widely different periods. Here the facts of present distribution serve to make us hesitate. Different altitudes, different soils, different conditions of moisture and so forth, produce to-day very distinct sets of animals and plants, even in the same immediate region. Or, if we are dealing with marine forms, a littoral and a deep-sea fauna of precisely the same age would be very different; indeed it is doubtless not an exaggeration to say that the present shallow-water fauna of the Atlantic coast resembles the shallow-water fauna of Middle Tertiary times much more than the deep-sea fauna of to-day. Considerations of this sort have led careful paleontologists to attempt to estimate the climatic and other conditions surrounding the subjects of their investigations; thus, for instance, Dr. Matthew, in discussing the Tertiary mammals of northeastern Colorado, concludes that one series represents a plains or prairie fauna, the other a forest one. These are not of the same age, but the difference between them is clearly to be attributed to environmental conditions as well as the lapse of time.

Thus in the course of our enquiry we come back to the modern biota, and find it necessary to ascertain as accurately as possible what conditions permit the existence and migration of the several species. Neither the blue flax nor the snail exists everywhere within the region which we said, in general terms, that they occupied. The flax occurs at various altitudes, up to 10,000 feet, but always in more or less open places, in dry or at least not very moist soil. The snail also lives at different altitudes, but in moist places under vegetation. Thus, although when plotted on a map the ranges of the two would appear to largely coincide, it is probable that they never, or almost never, actually exist together. While spreading over enormous areas, they have picked their way, as it were, from one suitable spot to another, showing thereby how closely they are dependent upon a particular set of conditions. In a general way, mountains may be said to favor the spread of both, and for either the desert is an impassable barrier.

When we have ascertained the necessary conditions of moisture, heat, light, etc., we have not nearly solved the problem. Very important, in nearly every case, is the living environment. In the case of the flax, we know that it is very injuriously affected by an orange rust (*Uredo lini* (Pers.) Schum.), which extends practically throughout its range. This rust infests not only the blue flax, but other species as well, including some of the yellow ones. Consequently, when two geographical groups of flax plants meet, whether they are of the same species or diverse, there is always a possibility that one will convey the rust to the other, supposing that they are not both already infested. The same sort of thing is true of diseases of animals, as many races of men have found to their destruction, upon mingling with the white

man. The competition between allied species is thus often indirect, one destroying another by conveying to it some disease.

The flax is visited by various bees, which I have studied and recorded; these carry the pollen from flower to flower, and thus aid in pollination. Whether the necessary bees are always present, is not yet known; but their presence in numbers must be a favorable factor, and thus an important element in the living environment.

In the case of the snail, although it is so common, we know little or nothing about its natural enemies.

The more we study living creatures the more we become impressed by the complicated conditions necessary for the preservation of the higher forms, and the possibilities of local or complete extermination. As we determine these more accurately, we feel able to return to the fossils, and from them restore the past in much more detail than at first seemed possible. If a snail or a slug crossed from Asia to America we presume that it not only found continuous, or nearly continuous, land, but also that it did not traverse any desert. The path of migration of the blue flax was not, it is virtually certain, across a lowland region or swamp. Making all allowances for what are called accidental means of transportation, it ought to be possible to infer something about the pathway of a considerable number of species.

In all of these researches, success and failure are inextricably mixed, at least as regards the details. In no case can we gather all the pertinent facts; our knowledge of even the commonest species is very deficient. Yet, when all is taken together, we find ourselves like the man who said he lost on every job, but was able to make money because of the multitude of them. The number of known species, living and extinct, is enormous, and the data we have gathered, when suitably sorted and arrayed, will point to many definite conclusions. More especially is there reason to hope for good results to be derived from studies which past investigations have merely suggested and shown to be possible.

As a matter of history, as food for the imagination, it is interesting enough to watch and take part in the reconstruction of the past, especially when we are able to do this with a reasonable degree of completeness, as at Florissant in Colorado, or Œningen in Germany. Much more, however, may come of these investigations. The problems of evolution, the intricate questions of heredity and variation, may be answered in part by such means as I have described.

The experimentalists, represented by Bateson, De Vries, Tower, MacDougal, Davenport and many others, have ascertained that what appear to be new species or races may arise suddenly by a process termed mutation. It even appears that in certain cases this process may be brought about by artificial means, such as differences of humid-

ity, or certain substances in solution, supplied at the proper moments. The obvious suggestion is, that species are more readily modified than is commonly admitted; and that in particular they are likely to be so modified on the borders of the territory they occupy, where they continually impinge on unaccustomed environments.

To show that this is possible is a most important step; but we still have to enquire how far has it actually occurred? In the case of our flax, we have an excellent example of the production of a new form on the periphery of the old, permitting expansion through modification; but only one such derivative seems to have been produced. In other instances, as the experimentalists have shown, the apparent instances are illusory, the supposed geographical segregates being merely examples of a single type variously modified by the direct action of the environment. The most striking evidence of this sort has been furnished by Beebe, who has produced in certain birds, by means of humidity, more difference that has been accepted as sufficient for the distinction of subspecies. Leaving out all such phenomena, we still have a great series of closely allied species, with undoubtedly inherited characters, presenting the same kinds of differences as have been observed to arise by mutation, sometimes apparently as the direct result of particular stimuli. What do these phenomena mean in the practical working out of evolutionary processes?

If we know in a general way the age of particular types and the extent of their migrations, we can begin to form an idea of their practical mutability. The vertebrate paleontologist finds evidence of remarkable changes within the Tertiary period, but even he has to admit that the course of evolution is not so rapid as it might seem; that new forms suddenly appearing must surely have migrated from other regions, where they doubtless underwent a slow process of development. Central Asia, we must now think, must have been the home of various groups, and will one day yield fossils of surpassing interest. Africa, once seeming so barren paleontologically, has of late begun to yield her treasures.

The student of fossil invertebrates finds the process of change to have been, in the majority of cases, extraordinarily slow; and the paleobotanist finds it slower still. It is not that plenty of specific forms were not produced, but the generic and higher types were so little susceptible to change. A wrong impression has been produced, even among the vertebrates, by the presence in different strata of remarkable extinct groups. No doubt two or three species of elephants walking about in our mountain-parks would give a strikingly different appearance to the Colorado landscape; but the time since this actually occurred is, geologically speaking, very inconsiderable, and does not represent any great step in the process of evolution. The more I study the

insects and plants of the Florissant Miocene, the more convinced I become that, speaking broadly, the extinct genera and higher groups are not the ancestors of any now living, but represent types which have failed, like the mammoth; while the real representatives of the modern biota show that there has been singularly little forward evolution in the course of perhaps a million years. Many of these are totally extinct in Colorado, but live elsewhere; thus the redwood differs little from that of California, while the wonderfully delicate and fragile *Halter,* belonging to a family no longer living in North America, is closely related to a living species of Persia.

Hence the experimental researches of De Vries and others, proving that mutation is a relatively common phenomenon among plants, prove perhaps too much. If change is so easy, why so little change, and that in the face of a radical change in temperature and moisture? It seems, indeed, that "elementary species" have always been produced in greater or less abundance, but by a sort of oscillation less related to the forward march of evolutionary activity than we might at first suppose. The ability to produce heritable segregates, especially in the face of adverse or strange conditions, is clearly of advantage, as giving new chances for spread or survival. Thus in the long run the tendency to break into "elementary species" would in many cases be favored by natural selection, without any necessity for each one of these, or even the majority, being directly related to a particular environment. There is no reason, apparently, why this should not continue for ages as an oscillation-process, a segregation in space rather than in time, producing thousands of species without overstepping the limits of the general group, or perhaps advancing at all in complexity. The molluscan genus *Ostrea,* the oysters, may be taken as an example of this; indeed, the modern oysters scarcely do justice to their Cretaceous ancestors. When it was generally held that species were created by divine fiat, it naturally appeared that he who should explain the origin of species might be given the rest without further charge. We are coming to see that there are diverse problems involved, and while the whole matter may well be locked up in the evolution of any single species, or indeed of any single cell, we begin to doubt whether we really possess the key.

Speaking philosophically, progressive or orthogenetic evolution—the existence of which no naturalist has any ground for doubting—must have a cause external to itself. All probability favors the idea that this did not operate once for all, but has continued in action throughout the ages. It may be found, perhaps, in the susceptibility of the hereditary mechanism to environmental influences of particular kinds, the nature of which remains for the present obscure. These reactions would fall under the operation of natural selection from the very

beginning; thus a too susceptible organism would quickly be thrown out of gear and would perish; a too conservative one, unless adapted to practically unchanging types of life, would equally perish. There would be a certain optimum susceptibility, which would be preserved, and would differ for different groups. More than this, certain kinds of susceptibility would be favored, and being once developed might, like bad habits, become harmful through the accumulation of results, resulting in extinction. Thus rapid evolution would usually go with a high percentage of failures, and a considerable number of grotesque forms, such as we see among the vertebrates. According to this view, the initiation of any evolutionary trend, except the oscillatory movements above described, would be exceedingly slow, and quite beyond the reach of experimental methods, other than those furnished by nature in the course of ages; hence, as Osborn has indicated, the great importance of paleontological researches. At the same time, while the processes which change the fundamental character of animals and plants may be too slow to observe, it is not to be doubted that very much light may be obtained by the experimental method, if only by way of showing us what it is that has been evolved—a thing we seem not to have clearly known. If the control of orthogenetic changes is reserved, as it were, for the gods—and we, doubtless, should only make a mess of it—we may be well satisfied if we can take advantage of the oscillation processes, which experimental researches are showing to be far more extensive and much easier to control than had previously been suspected.

LOYALTY[1]

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WHAT little I shall say is about personal loyalty. It is due myself that I should explain that the greater part of this address was written more than two years ago, and especially for my own students, who frequently have to meet certain ethical problems in connection with their professional work. Within a few months there has appeared a book upon loyalty by a distinguished philosopher[2] who deals with the subject in its broadest and best sense. I make haste, therefore, to say that I do not attempt to discuss the subject in any large sense. What I have to suggest is not spoken with the authority of the philosopher or with the philosopher's subtle reasoning. I can only give my personal impressions and views of the subject without regard to its philosophic bearings. I should add, however, that in Professor Royce's lectures you will find ably dealt with the many problems that naturally arise in connection with this subject. And whether you agree with all he says or not, you will find his book one of the most helpful and inspiring that has ever been published in our country.

I must premise also that what I say is said in a spirit of perfect frankness and on general principles, and has no reference to any particular occasions, circumstance or persons. The subject seems to be especially worthy of your attention just now because the habit of loyalty is one that may be cultivated during your student life; it certainly will not spring into full-fledged development at some future time when it happens to be wanted.

I am often asked about points of practical professional ethics, and it is chiefly in connection with this phase of the subject that I have thought that it would probably interest you. Loyalty is going to be an important factor in the making of your character, and even, if you care to look at it in that light, an asset in your profession, or in your business.

Perhaps I lay a little more stress upon this point because I come of a people who habitually place a high estimate upon every phase of loyalty. We seem indeed to have exaggerated or distorted ideas of

[1] An address to the student body of Stanford University, September 9, 1908.
[2] "The Philosophy of Loyalty," by Josiah Royce, New York, 1908.

loyalty, and we rather overdo the thing at times in the southern states where we keep up family feuds one generation after another, and vote with one political party all our lives through thick and thin. In his story of "Red Rock," Thomas Nelson Page expresses the more serious southerner's view when he says of the soldier, "It is loyalty, not success, that is knightly" (p. 145).

Without making any fine distinctions, I start with the proposition that loyalty is the most valuable attainment, if we may call it an attainment, or the most valuable trait of character, if that is a better name, that any man or any people can have in this life. And I challenge any one who questions this theory to put the matter to any test he chooses to apply from the highest moral standards down to the lowest commercial ones.

Now loyalty has to do with our relations to principles, to organizations, to communities and to persons. I would have it distinctly understood that I regard loyalty to a right principle as the highest type of loyalty, and the kind that must always be most satisfactory in the end. Practical illustrations of the importance of the professional forms of loyalty are constantly falling under our attention, and it is chiefly of these that I shall speak. These lower types consist in loyalty to organizations of various kinds and to individuals. As many people insist on the commercial standards of values let us see, if we can, what business men think of it.

When you get through your university studies and go out into the affairs of life, if you become employers of other men, you will lay great stress on the loyalty of those you have about you. You may not put it to yourselves in just this form, but if you are wise, you will none the less be influenced as much, or even more, by the loyalty of your employees than by any other one quality they may have. You will say of every man you engage: "If I can't trust this man to think of and work for my interests, I don't want him around, no matter how skilful he may be in his particular line of work."

If you seek employment under others you must surely count on having to meet this test yourselves, for this will be the unfailing attitude of your employers. And the more important the position you are to occupy the more weight will be given to this particular trait of your character.

The matter simply reduces itself to this, that a man who is not loyal is not wanted by anybody for anything.

In a business like that of mining, consulting geologist and the like, what do you suppose a man would be worth who was not loyal to the interests of his employer? How long would any one keep an employee who was not loyal? How long ought he to be kept?

Let us take a simple case: Imagine a man employed to examine

and report on a given piece of property who sells or turns over to outside parties information belonging to his employer, or who uses it for his own personal ends. Can anything be farther from the object for which men are employed, more base, more dishonorable?

Let us have the opinions of men of wide experience. I once recommended a young man for the position of assistant to one of the leaders of science in this country, who wrote back to make further inquiries, and wound up with this: "I want a man who is orderly, interested in the work and who will devote himself to my interests. If he will *not* devote himself to my interests I don't want him, no matter how competent he may be."

Dr. Rossiter W. Raymond, the venerable secretary of the American Institute of Mining Engineers, a man who has perhaps had a larger, more varied and more honorable career in connection with mining operations in this country than any other one man, says on this subject:[3] "Loyalty commands to-day the highest price in the market:" and he says much more to the same effect.

In one of the large banking houses of New York City this notice is posted up in full view of prospective customers: "If you can't cooperate, don't come round."

A few days ago I saw a letter from the manager of one of the largest mining companies in the world which contained the following reference to a man who had not been loyal to his employer: "I personally consider that a pick and shovel are the only instruments a man should be allowed to use who abuses his employer's confidence."

I doubt if the man who says this would want such a person about him even to use his pick and shovel. For if a man is not loyal, no one trusts him, no one feels comfortable with him around, and no one wants him at any price, or for anything.

Loyalty is so highly esteemed by most people that one is ready to overlook slow head, slow hands and slow feet where loyalty exists, while without it no skill or agility of mind or body makes one a desirable employee.

In large enterprises where many men have to cooperate, the lack of loyalty throws all the machinery of organization and administration out of gear; nothing runs smoothly.

Employees, assistants, partners and colleagues are wanted to help, to render service, not to hinder, to bring disorder and disorganization into an enterprise, no matter whether that enterprise is a great industry or a small one, a club, a fraternity, an organization of any kind whatever. No institution can long survive without the loyalty of its members to the common interest and purposes of its organization, and to each other.

[3] *Engineering and Mining Journal*, June 23, 1906, p. 1199.

It may occur to you that it is too much to ask that self-respecting men should fall down and grovel in the dirt at the feet of every selfish dollar-chasing employer. Nothing of the sort is expected. A loyal man can not only stand up straight, but he can stand just a little straighter than any one else, for no one so much as he has the mind conscious of rectitude.

You may fairly ask what is to become of loyalty when the conditions make it impossible. One always has a remedy in his own hands: he can quit, and carry with him a gentleman's self-respect, for without that there can be no loyalty worthy of the name.

There are certain things that loyalty does not demand of us. For example, it does not require us, in being loyal to one person, to be disloyal to others. Environment and education often lead us to look at things differently, and honest men may conscientiously differ, but we are bound to respect the attitude of other people, or as Professor Royce puts it, to be loyal to the loyalty of others.

Again, loyalty should not lead us into excesses that work wrong to others. It is a common misconception of loyalty to imagine that one must back his personal friend for anything and everything he happens to want, regardless of whether he is fit for it, and regardless of the rights of others. It is unnecessary to say that such an attitude is not tenable. Loyalty to the principles of justice and right will not permit that sort of thing.

But there are usually two parties to loyalty, especially in matters of employment and in all organizations where there are superior officers under their various titles or wherever the personal element enters. It can not all be on the side of the employee or of the subordinate. The employer, the head of the firm, the superior officer and the organization itself owes loyalty to employees, to partners and to colleagues. And it is this loyalty to each other that constitutes *esprit de corps,* that enables organizations to pull together, to work to a common end, to act in concert, to stand together in all things and to one big purpose. Moreover, those who expect loyalty are bound by every sense of decency and propriety to be worthy of loyalty, and to be loyal in return to those of whom loyalty is expected; that is a *sine qua non.* No one can long be loyal to a man who backbites, belittles or sneers at his employees or his colleagues behind their backs.

And what I say of loyalty is true not only here among us, in our own community, in our own country, and in our own time, but it is equally true of every quarter of the globe and of every age.

In commending loyalty to you I am not raising any questions about right and wrong. And even if I should raise such questions, there are, as Professor Royce points out, conflicting loyalties. I suspect that loyalty, like love, is blind. Who, when he sees his brother attacked,

stops to ask whether his brother has the right of it? The loyal man simply says, "We'll settle that later, but for the time being I stand with my brother." And loyalty doesn't look to see whether the battle is to be lost or won.

Remember too that loyalty, like charity, begins at home. When can one see a finer sight than that of a family that stands compactly together, helping and encouraging one another within, and defending each other from without.

As students in this, to you, new community, I trust you will ever remain loyal to the high resolves you bring with you, loyal to the communities, the schools and the friends you have left behind, and that you may cultivate here a new loyalty to your *alma mater,* to your class, and to whatever organizations you belong, and above all loyalty to the purposes of your education. Never lose sight of the important fact, however, that loyalty demands submission to the rules of your order or organization; no properly constituted society will admit a member who will not subscribe to its constitution and by-laws. In practise you will not be called upon to do anything spectacular, but you will have to impress upon yourselves the necessity of steadfastness of purpose.

And don't expect too much of anybody. We are all human, and human frailties are in our blood and bones. . Whether the object of your loyalty to a person, an organization, a party or a principle, you must not expect it to be perfect. None of the relations of this life are altogether satisfactory.

As a citizen be loyal to the legitimate and reasonable interests of the community in which you live, and you will not be found lacking in loyalty to the country at large. It is of loyal citizens and of loyal citizens only that great nations are made. Tyrants can not long oppress, nor can powder and bullets conquer, a people permeated with and true to such sentiments.

You will note that loyalty demands that you assume certain risks. This is inevitable. Loyalty without risks must be of a pretty poor quality. If there is anything especially pusillanimous in human nature, anything that one instinctively despises, it is the disposition to stand aside when there is danger to be faced, or to wait to see which side is going to win before choosing that particular side. Take the risks and go cheerfully forward.

Loyalty is one of the big and far-reaching virtues; it makes trustworthy men and great men; as a national virtue it makes a people great. For if it is love that makes the world go round, it is loyalty that holds the world together.

THE STORY OF PROFESSOR RÖNTGEN'S DISCOVERY

By ELMER ELLSWORTH BURNS
CHICAGO, ILL.

THE discovery of X-rays was announced by Professor Röntgen in December, 1895, in a communication to the Physico-medical Association of Würzburg. The date of the discovery is commonly thought to be November, 1895. As a matter of fact, the first X-ray photograph was made about two years before that time, and the accidental production of this photograph was the starting point of a series of investigations which continued for more than two years before the public announcement was made. The story was told to me by Dr. T. S. Middleton, now a physician in Chicago, who was a research student under Professor Röntgen during a period of four years, including the time when the great discovery was made.

Professor Röntgen is a man who works unceasingly as a teacher and in research, a man who brings to his students the inspiration of genius. Like Edison, he would often forget to eat were he not reminded by friends of his need of food.

He was working with cathode rays and, being an expert glass blower, prepared his own tubes. He had a habit of using his lungs as an air-pump in exhausting his tubes. Long practise had developed an athletic pair of lungs, so that he was able in this manner, aided by the increase in vacuum due to the electric discharge, to produce a vacuum sufficiently high for the production of the cathode rays. The first X-ray tube was exhausted in this way. This tube was blown to form a large bulb at the middle and bent to form a letter S at either end.

The electrodes being at the ends, the cathode rays would have to traverse the bends of the tube. Röntgen regarded the cathode rays as streams of electrified particles and believed that friction would be developed as these particles streamed past the bends of the tube. He expected this friction to result in new phenomena.

On a flat-topped desk in Professor Röntgen's private office lay an unassorted heap of books, glass tubes, photographic plate holders, platinum and aluminium electrodes, and what-not, such an unassorted heap as is likely to accumulate on the desk of a busy man. In this confusion it happened that a large book which the professor had been reading lay on a photographic plate holder. In the book lay a key serving as a bookmark. The use of a flat key as a bookmark is a pe-

culiar habit of Professor Röntgen's, a habit which leads often to the finding of lost keys by shaking open the books on his desk. The professor was working with the Crookes tube referred to above, observing the beautiful yellowish-green fluorescence which characterized this particular tube, when his wife came to call him to lunch. Laying the tube, still glowing, on the book he obeyed her summons.

Now Professor Röntgen is an enthusiastic amateur photographer, in fact out door photography is his recreation. Returning from lunch, he took the plate holder which had lain under the book, with other plate holders, and made several outdoor exposures. On developing the plates a shadow picture of a key appeared on one of them. Much puzzled, he showed the negative to some of his students, asking them to suggest some explanation of the mysterious key. None of their suggestions proved satisfactory, and he was up early the next morning searching for a solution of the mystery.

He determined to repeat precisely the operations of the preceding day and, remembering the positions of the glowing tube, the book, and the plate holder, he placed them as before, leaving them for the same length of time as on the preceding day. On developing the plate, the image of the key again appeared. The key was found in the book but the mystery was not solved. Here was indeed a strange thing. Of course it was known that the cathode rays would affect a photographic plate, but here between the plate and the source of the rays were a book and the hard-rubber slide of the plate holder, both of which are impervious to light, and the cathode rays were confined by the walls of the tube.

Röntgen continued his investigations and found that the rays from his tube would penetrate other objects, but in different degrees, and because of this difference in transparency he could obtain shadow pictures of many interesting objects.

The fluorescence of his tube suggested to him that other substances than glass might be caused to fluoresce by the radiation from the tube. An interesting field was opened before him. Other research was suspended. Visitors were excluded, and with his research students the work was continued. Fluorescent liquids were tested, one of the first being a solution prepared from the horse-chestnut. The number of fluorescent substances tested, including liquids and solids, was not less than fifty. One of these was barium platino-cyanide, the fluorescence in this case being caused by the newly-discovered radiation acting through a black cardboard. Convinced by a long series of observations of the photographic and fluorescent effects obtained from his tube that he had discovered a new form of radiation, Professor Röntgen made his public announcement.

In answer to my question regarding the date of the incident nar-

rated above, which marked the beginning of the great discovery, Dr. Middleton said that he had made no effort to remember the date. "Was it earlier than November, 1895," I asked? "Yes. It was at least two years earlier" and, recalling some incidents to aid in fixing to date, he continued, "It was soon after the opening of the autumn semester. It could not have been later than October, 1893. Possibly it was in 1892."

Professor Röntgen, being a reticent man, has not given to the world the details of his discovery. His announcement was that of results arranged in logical not chronological order. This narrative from an authentic source fixes the date of the discovery of X-rays at least two years earlier than that which is commonly accepted. Moreover, it shows us the great German professor in the light of a man who carefully and patiently worked out his problem to his own satisfaction before announcing his discovery to the world.

A GREAT PERMIAN DELTA AND ITS VERTEBRATE LIFE, WITH RESTORATIONS BY THE AUTHOR

By Dr. E. C. CASE.

ASSISTANT PROFESSOR OF HISTORICAL GEOLOGY AND PALEONTOLOGY, UNIVERSITY OF MICHIGAN

As early as 1878 it was known that the remains of a wonderful group of animals lay hid in the rocks of north central Texas, that had lived their appointed time and passed away before the earth history was half completed; since then collectors have gone into this region more or less regularly, contending in the early days with hostile Indians and later with bad water and difficult transportation. Since 1895 the author has made several trips, gathering vertebrate fossils for the University of Chicago and the American Museum of Natural History in New York. The descriptions below are based on these collections and those of earlier workers.

Perhaps one can get the best idea of the age of the rocks and the fossils by remembering that they were laid down in the portion of geological time called the Permian age, just after the period of the coal deposition. Reckoning the completed history of the earth as about one hundred millions of years, these rocks and fossils are from thirty to forty millions of years old. At the beginning of the Carboniferous age, when the coal was laid down, the part of the continent that is now called the Mississippi Valley was covered by a wide sea, but during this age there was a progressive shallowing which culminated in the elevation of the Appalachian mountains in the east and the appearance of dry land from the new mountains on the east to the forebears of the Rockies on the west.

The appearance of dry land was at once the cause of the development of the wonderful group of Permian animals and the reason that so few are preserved to us, for it is only when the hard parts of animals or plants are buried in some water-soaked layer of the earth or are covered by water that they can be petrified and preserved. If they remain exposed to the air they are soon destroyed; so, of the skeletons of the thousands of buffalo left lying on the plains but a few years ago, there remain to-day but a few rotten and frost-split horns and bones. Undoubtedly in the muddy banks and bars of the rivers there are skeletons undergoing the slow process of petrifaction which will preserve them to be the chief treasure of some future museum. And so because of the land conditions which prevailed over so much of the

continent the record of the great land fauna of the Permian age is very faulty and imperfect. It is only in some exceptional place where large quantities of bones were swept together under favorable conditions that they have been preserved and such an exceptional depository occurs in northern Texas.

When the Appalachian Mountains were raised an extension of their southern end reached across what are now Arkansas and Oklahoma, terminating in the Wichita Mountains in western Oklahoma. North of this range rose a broad upland reaching from the Rockies to the Appalachians and to the Canadian line on the north; south of the mountains a shallow sea reached nearly to their base, and some

FIG. 1. VIEW IN WILLBARGER COUNTY, TEXAS, showing the character of the beds in which the bones occur.

great rivers, from the mountains and the uplands, poured their flood waters into the sea and built up a great delta. The remains of animals which haunted the banks of the rivers were swept into them in time of flood and carried out to be deposited in the delta, which covered most of what is now Wichita, Archer and Willbarger counties in the state of Texas. Naturally most of the remains which found their way into the streams were already fragmentary, as they had rotted on the bank and been torn by predatory animals, but in their course to the sea they were farther disintegrated, so that, rolled by the rivers and beaten by the waves, they sank to their burial as little more than water-worn fragments; ends of limb bones, isolated vertebræ and broken skulls which do

little more than tantalize the student with the hints of new forms and new relationships which can not be verified. In some places these water-worn fragments are so thick upon the ground that they can literally be shoveled up by the wagon load. In some rare instances the bodies of animals found their way unharmed into the water and, distended by gases of decomposition, floated far and uninjured until they came to rest on some mud flat beyond the reach of sharks or other predatory animals. Such skeletons are preserved entire and in a most wonderful state of preservation, but they are exceedingly rare, not more than one turning up in a season's search.

Of all the wonderful animals revealed by their petrified remains, perhaps the most striking are the reptiles. The reptiles made their first appearance in the Permian or in the latter portion of the Carboniferous preceding, but here at the very inception of their line they developed a great diversity of form and habit. There were aquatic and terrestrial forms, carnivorous, herbivorous and omnivorous forms, forms simple and closely resembling their amphibian ancestors and forms so bizarre in their structure that the world has produced nothing more strange. The reptiles descended from the amphibians and it is natural to look in these beds, where the lowest of the reptiles are found, for the connecting link between the two, but as yet this form has not been discovered; the approach from both sides, however, is so close that it is frequently impossible to determine the nature of a specimen from a single bone or small portion of the skeleton.

The simplest of the early carnivorous reptiles were aquatic, living in the waters of the great rivers or perhaps even in the ocean. The body was long and slender and the tail was exceptionally so, in correlation with the swimming habit. Aside from the more technical points, the interest in the development of the primitive reptiles centers in certain changes of the teeth and the dorsal spines of the vertebræ. In one of the simplest forms, *Poliosaurus*, the teeth have the form of simple cones of nearly equal size in all parts of the jaw; such a dentition indicates that it preyed upon small animals which it seized and swallowed whole after the manner of snakes and many lizards. The dorsal spines are low and do not project beyond the skin. The animal probably resembled very closely the living monitor of the Nile.

In another and closely related reptile, *Theropleura*, the teeth have become differentiated, those at the anterior end of both the upper and the lower jaws, the incisors, are enlarged and have taken on the appearance of tusks; posterior to the incisors there is a slight notch in the edge of the upper jaw, caused by the growth of the lower incisors, and posterior to this there are tusk-like teeth in the upper jaw, the canines. The growth of the incisors and canines increased the power of grasping and holding prey. Moreover, in the posterior teeth of the

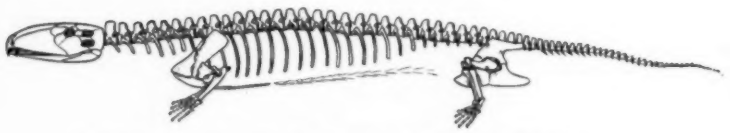


FIG. 2. RESTORATION OF THE SKELETON OF *Theropleura*.

jaws the teeth are somewhat flattened, so that cutting edges are developed which would lacerate the prey in capture or before swallowing and minimize the chances of escape. In *Clepsydrops* the dentition is still more specialized; the incisors and canines are longer and the notch between them has developed into a toothless diastema; the skull is rather thin and high and the eyes are located far back in the skull. The spines of the vertebræ are very high and project from the back like the fin of a fish, in this matter contrasting strongly with the simpler forms in which there is no such fin or frill. It must be remembered that the spines are connected directly with the vertebral column and are not simply developed in the skin as is the case with the fishes. In the modern *Basiliscus* and *Iguana* there are frills on the back, but the strengthening spines are dermal like those of the fishes.

In *Dimetrodon,* the last of the series, these characters reached their culmination. The incisor and canine tusks have attained a relatively enormous length and strength, and projected from the jaws as much as three inches; the diastemal notch is larger and deeper and the posterior teeth of the jaws are recurved and have sharp serrate edges so they had all the cutting power of a Malay kris. Could a more effective arrangement be imagined for the cruel business of capturing and holding living prey despite its desperate struggles? The spines on the back developed to enormous length and in some forms tapered to the slenderness of a whip lash. The tail was short and the feet strong and with well-developed claws, all going to show that the animal was terrestrial in habit. The largest species of *Dimetrodon* reached a length of about eight feet and was easily the largest, strongest animal of its time. We can imagine this fiercely carnivorous form crouching in the bushes or tall grass on the side of some stream and making a

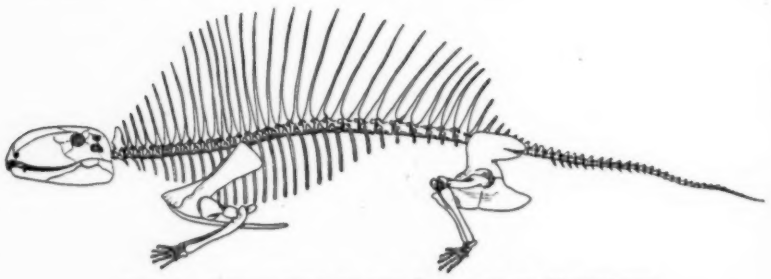


FIG. 3. RESTORATION OF THE SKELETON OF *Clepsydrops*.

fierce scuttling rush out upon its prey, perhaps some slow-moving reptile or amphibian, perhaps even some smaller individual of its own kind, for there is ample evidence that these animals waged fierce battles among themselves. It is not uncommon to find bones which have been broken during life and healed again, telling of furious reptilian contests in the struggle for mates or for territory, or perhaps with the single idea of a cannibalistic meal.

But a more wonderful animal still has left its remains in the rocks. In this form there were high spines on the back, but instead of the spines being simple they were furnished with projecting processes on the sides, not unlike the yard-arms of the old-fashioned sailing ships. This resemblance led Cope to call the animal *Naosaurus,* ship-lizard. In a recent restoration of *Naosaurus* it has been given the skull of the fiercely carnivorous *Dimetrodon,* the general similarity of the forms

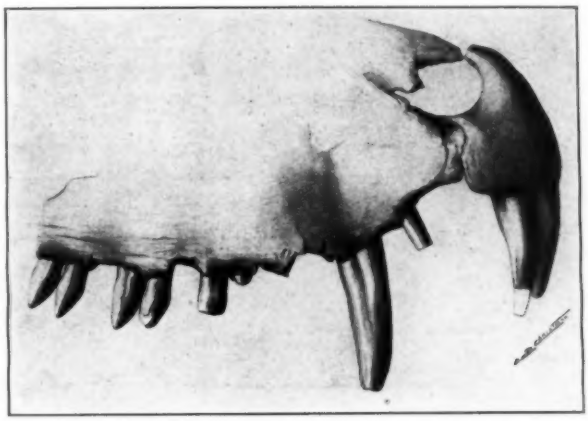


FIG. 4. ANTERIOR PORTION OF THE JAW OF *Dimetrodon,* showing the great tusks.

seemed to warrant this, but recent discoveries have made it probable that *Naosaurus* was not an eater of flesh, but a peaceful, sluggish eater of shell fish and perhaps of vegetation. This animal has perhaps the most wonderful dentition of any known animal the incisor teeth are sharp and chisel-shaped, such as might be useful in cutting strong vegetation; behind these are five sharp triangular cutting teeth, not unlike the sectorial teeth of such flesh eaters as the tiger and lion; behind these are simple cones, such as would be useful in holding a struggling victim. But most wonderful of all, on the palate and in a corresponding position on the lower jaw were heavy plates of bone, covered by short stumpy teeth, such as occur in the jaws of fish which live upon molluscs. The animal was seemingly omnivorous, but instead of having a dentition of a generalized pattern like that of the pig or the human being, there was a set for each kind of diet. The

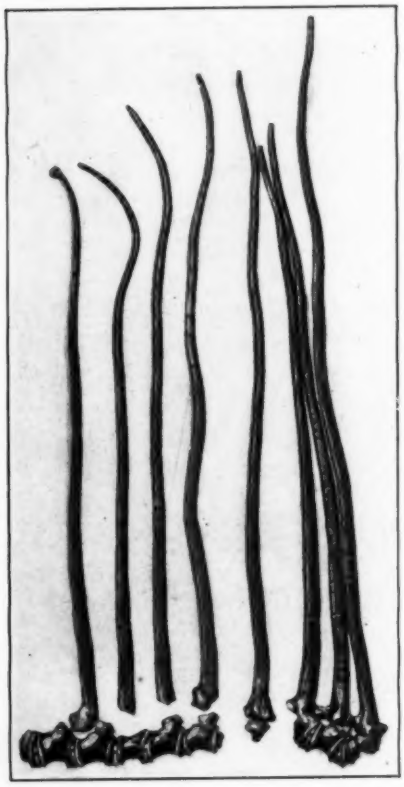


FIG. 5. PORTION OF THE VERTEBRAL COLUMN OF *Dimetrodon*, showing the enormous development of the spines.

discovery that *Naosaurus* was an eater of molluscs and not a predatory form makes more perplexing than ever the question as to the use of the spines on the back. On such a thick-bodied, sluggish mud-grubber, the cross-barred spines must have had about the same value as an ornamental frieze on a canal boat. What conditions of environment could have produced similar structures on creatures of such dissimilar habits as *Dimetrodon* and *Naosaurus?* It is as if the tiger and the badger should meet on common ground and develop highly specialized, unwieldy and seemingly useless structures of close similarity.

Of what use were the spines on the backs of these animals? The structure shows that they were not covered with flesh, but were united by a thin membrane through which the spines showed as plainly as the fin rays in the fin of a fish. It is hard to conceive of this great

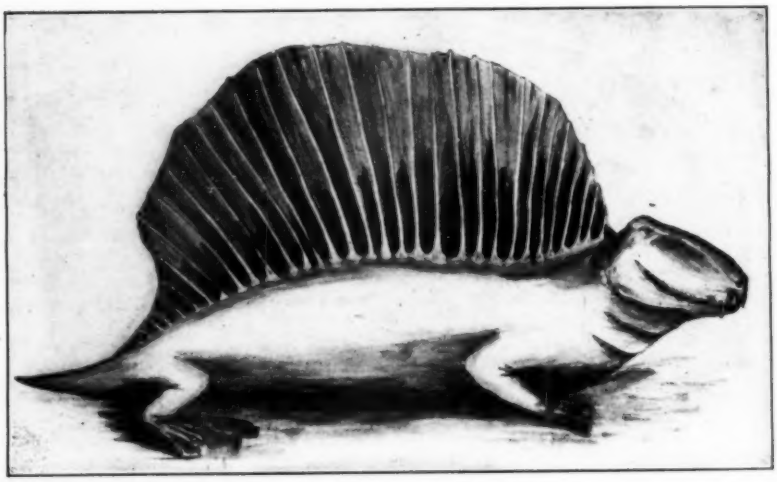


FIG. 6. RESTORATION OF *Dimetrodon*.

dorsal frill as anything but a hindrance to any quick movement. Cope suggested, in a spirit of fun, that these animals were the precursors of the modern fin-keeled yacht and that when they wished to navigate the Permian waters they swam upon their backs. Other authors have suggested equally abused uses in a similar spirit, but there are very few that can be considered with any degree of seriousness. The obvious suggestion is that the spines served as some form of protective mimicry, perhaps helping the animal to remain concealed among the reeds which bordered the lakes or streams, but this seems hardly necessary when we reflect that the animal was the dominant form of its time and needed no concealment unless it was to aid in lying in wait or in making an unseen approach until sufficiently near for the final rush upon its unsuspecting prey. This last is perhaps a fair suggestion, but it seems that the physiological burden of maintaining such an essentially weak structure must have far outweighed any conceivable advantage of concealment. The spines were slender and were constantly subject to fracture in battle or by accident and the animal must have expended no inconsiderable portion of its energies in repairing the broken structure.

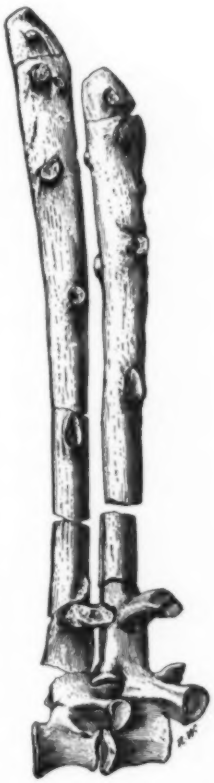


FIG. 8. SIDE VIEW OF TWO DORSAL VERTEBRÆ OF *Naosaurus*.

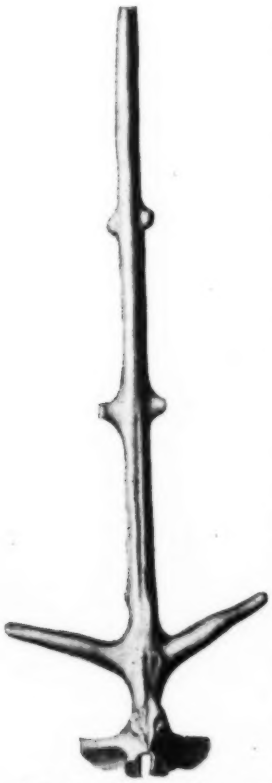


FIG. 7. FRONT VIEW OF ONE OF THE DORSAL SPINES OF *Naosaurus*.

There remains the suggestion that the spines are remnants of a formerly useful structure and their present condition is purely a physiological one due to overgrowth. It seems certain that when a structure has developed so far as to give an animal a great advantage it may continue to grow until it is rather a burden than a help. The structure starting as a protective feature may give the

animal such an advantage that it is practically free from all its enemies and in this dominant or protected condition it may become overnourished and the originally useful structures may continue to grow by a kind of inertia or momentum until they become greatly exaggerated masses of flesh or inordinately developed spines, horns, feathers, etc. Such a development seems to have occurred once and again in the history of the world, and the most bizarre types of life owe something of their condition, at least, to this principle. The late Professor Beecher, of Yale, has shown that there is a decided tendency, both in plants and in animals, for a species that is nearing the point of its extinction to develop a spiny or horny habit, covering itself with all sorts of excrescences, seemingly in an unregulated effort to find some condition which will prolong its existence. It is certain that these reptiles, dominant as they were, were rapidly completing their allotted span and as the end approached the spines grew ever heavier and heavier, until it seems plausible to suggest that they became at last a great drain on the animal's powers of nutrition and hastened in no slight degree the end.

FIG. 9. PALATAL VIEW OF THE SKULL OF *Naosaurus*, showing the peculiar dentition.

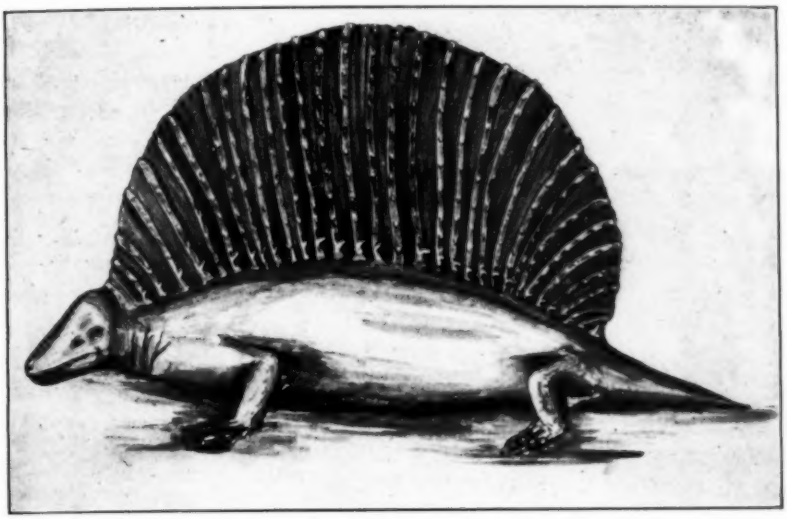


FIG. 10. RESTORATION OF *Naosaurus*.

The family of the high-spined *Pelycosaurs* did not monopolize the wonders of the reptilian horde; however the borders of the streams, the swamps and the uplands, harbored other forms whose structure is just beginning to be understood. One group of these, called by Cope the *Cotylosauria,* is the most primitive of the reptiles and the nearest to the amphibians. These animals were low-bodied and sprawling, with a head completely roofed over by bone and showing between the orbits the third, or pineal, eye. Rudiments of this third eye are still present in the human brain, the pineal gland between the cerebrum and cerebellum, and in many of the modern lizards it is still so far functional as to have a rudimentary retina perhaps capable of perceiving light.

Another group of reptiles closely resembling the *Cotylosauria* in outward appearance, but differing in many details, notably the development of a body armor, were placed by Cope in a separate order, the *Chelydosauria.* As indicated by the name, the *Chelydosauria* are probably the ancestors of the turtles. Aside from more technical points this relationship is shown by the development of a more or less complete carapace. The skeleton of the larger forms is pretty well known and the general shape is shown in the restoration of the skeleton of *Diadectes,* Fig. 11. The teeth are elongated transversely and flattened, telling of a purely vegetable diet; the dermal armor consisted of five overlapping plates on each side lying on the first five dorsal ribs; the anterior one is small, the second much larger and the last three smaller again. In certain small forms, *Otocœus* and *Conodectes,* the armor was much more perfect, consisting of strong dermal plates correspond-

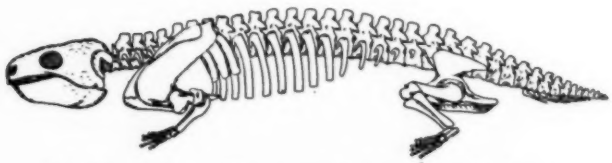


FIG. 11. RESTORATION OF THE SKELETON OF *Diadectes*.

ing to the ribs in number and extending down over the sides in broad curves so that the animal was completely closed in a bony cuirass. Add to this that the top of the head was heavy and solid, and we can imagine that the animal when it crouched close to the ground, with its head drawn down and in, resembled very closely the modern *Armadillo* in its attitude of defense and was able to resist the attack of even the long-tusked *Dimetrodon*.

This donning of armor is one of the striking things about the animals of the Permian age; it occurred among the amphibians as well as among the reptiles and is closely correlated with the development of great tusks in the predatory forms. As the armor-piercing weapons grew ever stronger the armor grew ever heavier and more completely adapted to the body. The same thing has happened once and again in the world's history; much later, in Tertiary time, when the world was thirty millions of years older, we have a repetition of the same thing. The great saber-toothed tiger developed canine tusks six inches in length, and the small edentates, the natural prey of the tiger, developed first small isolated bones in the skin, but ever as the tusks grew the bones in the skin became larger and better arranged, until the almost perfect protection of the *Armadillo* appeared. It was the prophecy of modern warfare between armor-piercing shells and armor plate, we have not seen the end in human history, but in the old days it continued to the practical extinction of both parties to the contest. Perhaps there is a neglected object-lesson here.

Turning from the reptiles to the amphibians, we find a no less wonderful group of animals. During the preceding age, the Carboniferous, the amphibians had been masters of the world; by the Permian, their time of dominance was past and they were already on the downward path that was to end in the obscure toads, frogs and salamanders of our meadows. But they were far from yielding tamely to their fate; they developed in all possible directions in a seemingly frantic effort to regain their lost dominance. During the Permian and the succeeding Triassic ages, there lived some of the largest amphibians the world has ever seen; they betook themselves to the water and developed eel-like bodies; they lived in hollow trees, as witness the discoveries of Sir Wm. Dawson in the stumps of trees

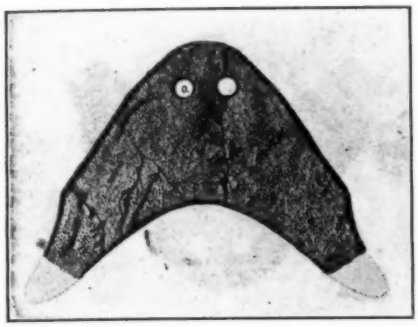


FIG. 12. SKULL OF *Diplocaulus*, showing the upper and lower surfaces.

FIG. 13. RESTORATION OF *Diplocaulus*.

in the coal beds of South Joggins in Nova Scotia; they wrapped themselves in armor and they hid themselves in the ground.

It is possible to describe but a very few of the forms that are known. *Eryops* was the largest of the amphibian tribe, with a length of about eight feet; it was not unlike a great overgrown newt or salamander with weak sprawling limbs that could not raise the body from the ground, except by a great effort. The skull had a length of two feet and a half in the largest specimens and the lower jaw was hinged at the posterior end of the skull, so that the animal had a most tremendous gape. The jaws were armed with sharp conical teeth, which in the anterior portions of the jaws were developed into powerful tusks. Probably the animal played a somewhat similar part in the Permian waters to that of the modern alligator, lying nearly covered in the water with only the eyes and nostrils exposed, which were placed on the top of the skull for the purpose, and gliding slowly upon its prey until within a distance that made possible a sudden fierce rush which ended with the passage of the victim down the capacious maw of the *Eryops*.

Contrasted with *Eryops*, and probably frequently its victim, was the small *Diplocaulus*. Though still imperfectly known, enough has been made out about this animal to show that it possessed a form even more grotesque than that of the high-spined reptiles. The head, as shown in Fig. 12, was extremely flat and shaped like an exaggerated crescent with strong horns or spines projecting to the rear from the posterior corners. The eyes and nostrils were located far forward toward the anterior end and were directed straight upward. The lower jaw was

very short and articulated with the skull far in front of the ends of the horns. No trace has been found of limbs, and the vertebræ interlock like those of the modern snakes; from this it is probable that these animals were limbless and snake-like in form, but they must have presented a most peculiar appearance with the slender body and enormous head. It is hardly possible that the animal could have raised its head from the ground except by an occasional and violent effort, for the skull was solid and relatively very heavy. Probably the animal was purely aquatic in habit and, lying in the mud of the bottom, wriggled forward, pushing its great head through the slime, from which it gathered the vegetation and small shell fish which formed its food. The position of the eyes and nostrils on the top of the skull renders this position the more certain. On the banks of the streams the amphibians took yet another form, for here they donned a complete coat of mail similar to that of the small reptile.

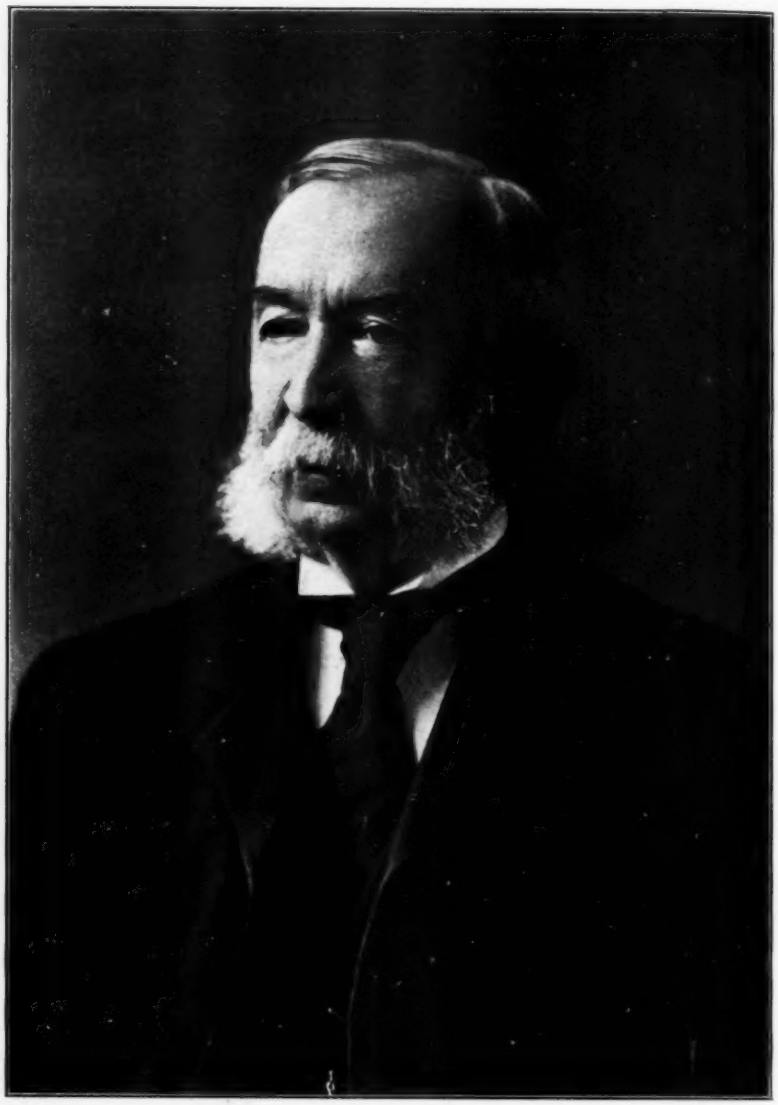
Imperfect as our knowledge still is of this wonderful group of animals, enough is already known to show how fully strife and warfare filled the world's history even at the beginning, and how every possible advantage of tooth or limb or armor was necessary for success.

THE PROGRESS OF SCIENCE

TWO GREAT UNIVERSITY PRESIDENTS

THE development of the American university during the last quarter of the nineteenth century is perhaps the most important chapter in our recent history. In this remarkable movement two institutions have led, and their prominence is personified in two great educational leaders, President Eliot, of Harvard, and President Gilman, of the Johns Hopkins. The oldest of our universities, with its high traditions, its faculty of eminent scholars and its alumni throughout the country, and the youngest of our universities, unentangled by precedents and engagements, free to plan its work and choose its

PRESIDENT CHARLES W. ELIOT.



PRESIDENT DANIEL C. GILMAN.

men, were the institutions best placed to lead the way, but they might not have done so had they not found the right presidents at the right time. From the point of view of this journal it is worth emphasis that both owed their preparation to scientific training and teaching. Dr. Eliot was professor of chemistry at the Massachusetts Institute of Technology when called to the presidency of Harvard, and Dr. Gilman was professor of geography at Yale when he took up administrative work.

Dr. Gilman resigned the presidency of the Johns Hopkins in 1901, on reaching the age of seventy years and after twenty-six years of office. His death

last month recalls vividly his great services to higher education. Dr. Eliot has now resigned the presidency of Harvard to take effect next spring, when he will have served forty years in the office, and will be in his seventy-fifth year. Mr. Gilman was at the time of his resignation in full vigor of body and mind and was able afterwards to undertake the difficult task of organizing the Carnegie Institution, while performing many other public services. President Eliot has never seemed more competent to direct the affairs of a university than at present; there has not during the past forty years been a time when he has been so gladly followed as a leader. He is likely to remain for years to come the chief influence at Harvard and the leading private citizen of the United States.

At the inaguration of Mr. Gilman as president of the Johns Hopkins University on February 22, 1876, Mr. Eliot said: "In the natural course of your life you will not see any large part of the real fruits of your labors; for to build a university needs not years only, but generations." This is only partly true. The traditions and ideals of the university are a long growth, but they may be transplanted to a new soil and flourish there. Relatively to other institutions at least, it is probable that the Johns Hopkins will never again be so great as it was in the eighties, and Harvard will never again be so pre-eminent as it is at the close of Mr. Eliot's administration. The seven professors on the faculty of the Johns Hopkins at the beginning far surpassed the average of any present faculty, and the hundred students in the early years, the average of any present student body. This great feat was again repeated by Mr. Gilman when the medical school was organized. Harvard has accomplished more in the past forty years than during the preceding centuries of its history. It set standards of freedom and culture when such standards were most needed. It now shares its leadership with other institutions and will probably fall behind the greater of the state universities.

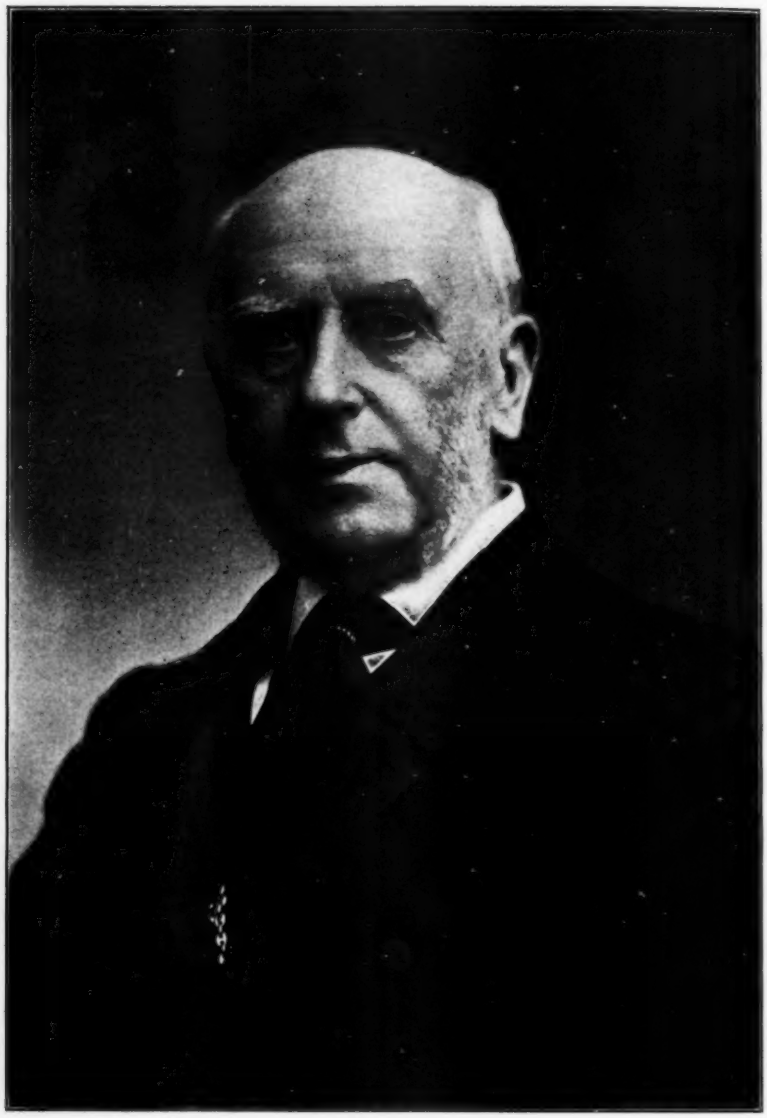
There is more instinctive admiration for the puritan aristocrat than for the opportunist, but in so far as Mr. Eliot stands for the plan of free electives, for culture prerequisite to the professional school, and Mr. Gilman for a group system of studies leading chiefly to the professional school and research, the majority of scientific men will side with the latter.

Mr. Eliot's position could only be filled by a man of equal distinction after forty years of service. It is probably well that it can not be filled. The constitution of the state of Massachusetts places measures before men. It is better for the university to be a democracy of scholars, rather than for its scholars to be subject to the will of one man. The Harvard corporation will not purposely reorganize the university on a democratic and representative basis, but they will probably contribute to this end by the president whom they will elect.

SCIENTIFIC ITEMS

WE record with regret the death of O. T. Mason, head curator of anthropology in the U. S. National Museum; of Dr. Francis H. Snow, formerly chancellor and professor of entomology in the University of Kansas, and of Professor Berger, the eminent French surgeon.

THERE was held at the Sorbonne in Paris, on October 4, a meeting in memory of the great chemist, Marcellin Berthelot. M. Raymond Poincaré made an address on his work, and was followed by M. Fallière, president of the Republic.—A bronze tablet to the memory of the late Major James Carroll, eminent for his work on yellow fever, was unveiled in the main medical building of the University of Maryland, on November 11. Dr. William H. Welch delivered the principal address.



SIR ARCHIBALD GEIKIE,
The Eminent Zoo'ogist, elected to the Presidency of the Royal Society.

BY the will of the late Grace M. Kuhn, Harvard University receives $175,000 to endow a department of biological chemistry.—The Draper's Company will erect for Oxford University an electrical laboratory at a cost of £22,000 and will give an additional sum of £1,000 for its equipment.

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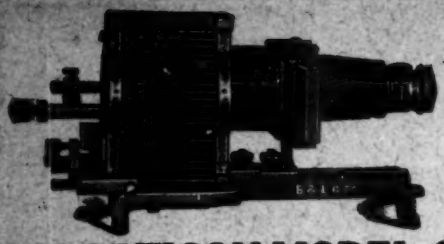

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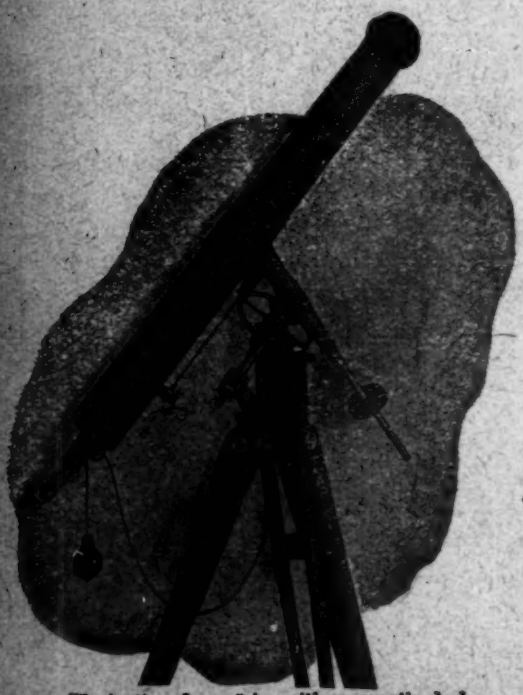

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